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COMMITTEE ON THE PEACEFUL USES
OF OUTER SPACE

INTERNATIONAL COOPERATION IN THE PEACEFUL USES OF OUTER SPACE - ACTIVITIES OF MEMBER STATES

Note by the Secretariat

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1. The Working Group of the Whole to Evaluate the Implementation of the Recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82), in paragraphs 4, 5 and 6 of the report on the work of its fifth session (A/AC.105/483, annex II), made recommendations concerning the preparations of reports and studies by the Secretariat and the compilation of information from Member States.

2. The Working Group recommended, in paragraph 4 (b) of its report, that the Committee request all Member States, particularly those with major space or space-related capabilities, to submit an annual national report to the Secretary-General on their space-related activities in which there could be greater international cooperation, with particular emphasis on the needs of the developing countries.

3. The Working Group also recommended, in paragraph 4 (h), that the Outer Space Affairs Division prepare on a regular basis an updated report on the resources and technological capabilities of States in the fields of space activities for the promotion of cooperation in the peaceful uses of outer space, on the basis of information provided by them.

4. The report of the Working Group was adopted by the Scientific and Technical Subcommittee at its twenty-eighth session (A/AC.105/483, para. 22) and the recommendations of the Working Group were endorsed by the Committee on the Peaceful Uses of Outer Space at its thirty-third session 1/ and by the General Assembly in its resolution 46/45 of 9 December 1991, paragraph 10.

5. The Secretary-General subsequently addressed a note verbale dated 14 August 1991 to all Member States, requesting them to communicate to the Secretariat, by 1 October 1991, the information requested in the above-mentioned recommendations.

6. The Secretary-General also drew the attention of Member States to the recommendation of the Committee, as contained in paragraph 149 of its report:

> "The Committee recommended that the Secretariat should invite Member States to submit annual reports on their space activities. In addition to information on national and international space programmes, the reports could include information in response to requests from the Working Group of the Whole as well as information on spin-off benefits of space activities and other topics as requested by the Committee and its subsidiary bodies." 2/

7. In accordance with the recommendation of the Committee, the Secretary-General further suggested to Member States that information in response to those requests could be submitted in a single report on national space activities, with an indication of information that responds to specific requests from the Working Group.

8. The present document was prepared by the Secretariat on the basis of information received from Member States as of 17 December 1991. Information received subsequent to that date will be included in addenda to the present document.

Notes

1/ Official Records of the General Assembly, Forty-sixth Session, Supplement No. 20 (A/46/20), para. 31.

2/ Ibid., para. 149.

CHINA

[Original: Chinese]

China's outer space policy seeks energetically to develop the use of satellites for national economic and social development; to further, through the development of space applications, the use of satellite and space technology; to promote the transfer of space exploration research and space technology to other areas of technology; and vigorously to promote international cooperation.

I. SATELLITE APPLICATIONS

China has successfully launched and recovered 12 recoverable remote-sensing satellites and obtained much valuable data for territorial and geolcgical surveying, irrigation development, petroleum exploration, mapping, environmental monitoring, railroad and highway construction, engineering site selection and urban planning, which have been of great economic benefit. For example, satellite images have made it possible to complete the mapping of the Yellow River delta on a scale of 1:50,000 and 1:100,000 and a comprehensive management and development programme has been implemented in three northern regions (Beijing, Tianjin and Tangshan).

The Chinese Government has successfully used such space technologies as remote sensing and satellite communication in conducting experiments related to natural disaster detection, forecasting, damage assessment and defence. Relatively positive results have been obtained in providing protection against such natural disasters as floods, earthquakes, forest fires and typhoons, helping to reduce losses caused by such disasters and protecting human life, property and safety.

The Chinese Government's pressing need to link natural resources and environmental management has prompted it to set up a series of major remote-sensing projects. These include:

(a) A remote-sensing survey of soil erosion on the loess plateau; charts showing land use, land resources and soil erosion have been prepared for use in regional administration and planning;

(b) A comprehensive remote-sensing survey of three northern wind-break forest zones; charts on a scale of 1:500,000 showing forestry resources, soil use and forest-establishment criteria, etc., have been prepared and a regional geographic information system has been established to provide a technical basis for assessing the environmental benefits of such forests and managing and planning of regional forestry resources;

(c) Remote sensing for flood control along the Yangtze and Huaihe rivers; a quasi-real time aerial remote-sensing flood-monitoring system has been established;

(d) Crop yield (rice, wheat and maize) estimates through remote sensing;

(e) Remote-sensing surveys of mineral resources (gold and coal deposits, etc.);

(f) Survey of desertification in China's northern regions;

(g) Marine environmental monitoring.

China has launched five communications satellites, increased its leasing of satellite channels and established a national television, televised education and satellite information network. This has helped China's communications and broadcasting industry to advance significantly and transformed the educational, cultural and informational backwardness of the country's remote areas. There are already 30,000 satellite television receiving stations in the country and 10 television and phonetic broadcast programmes are transmitted by satellite. Over 1 million elementary and secondary schoolteachers have been trained via televised courses broadcast by satellite. Apart from mass communications, more than 200 satellite circuits have been opened up for the petroleum, coal, irrigation and electricity sectors; in the financial sector, satellites have been used by the data transmission service of the People's Bank of China: 350 substations link the central bank and the main branches, thus using technology to modernize the Bank's administration.

II. APPLICATION SATELLITES

China is currently developing the DFH-3 communications satellite, the FY-2 meteorological satellite and the CBERS Earth resource satellite. The Long March 3 (CZ-3) launch vehicle is scheduled to launch China's sixth operational communications satellite and the country's first geostationary weather satellite at the Xichang launching site in the near future.

III. SPACE RESEARCH ACTIVITIES

1. Satellite exploration

When the FY-1 meteorological satellite was launched by the CZ-4 launch vehicle on 3 September 1990, a pair of balloon-satellites, QAQ 1-1A and QAQ 1-1B, with diameters of 3 m and 2.5 m respectively, were put into orbit at an altitude of 900 km. Having completed their survey measurements of upper atmospheric density, the two balloon-satellites fell to Earth on 12 March 1991 and 23 July 1991, respectively.

On the FY-1 meteorological satellite, semiconductors were used to detect high-energy particles and to carry out multiple soundings of a solar proton event and its heavy nuclear composition.

2. Rocket exploration

On 22 and 26 January 1991, two small-scale Zhinu-3 sounding rockets were launched for the first time from Hainan Island. The principal specifications of these rockets are: length, 4.87 m; diameter, 0.25 m; weight, 285 kg; payload, 50 kg. The two rockets attained heights of 147.5 km and 137 km, respectively. This series of rockets is important for measuring low-latitude ionospheric anomalies and the parameters of the upper atmosphere.

3. High-altitude scientific balloons

In 1990, China launched a total of 10 high-altitude scientific balloons which carried out the following major activities:

(a) Infrared telescopic observations: second-mirror vibration and offset star-tracking technologies were used to detect cosmic infrared radiation;

(b) A 500-cm^2 xenon MWPC was used to detect hard X-rays in space;

(c) A photon counter was used to measure aerosols in the atmosphere;

(d) Seeds were transported for use in genetic research.

In addition, during 1990-1991, China and the Soviet Union cooperated in conducting three extended balloon flights (one of which was unsuccessful), carrying a magnetic spectrometer spark chamber with a total weight of 1.3 tons, to carry out primary cosmic-ray research. The balloons were launched from Hebei and Liaoning provinces in China and were recovered in Kazakhstan, USSR, after covering a total of over 4,000 km.

In 1990, China successfully conducted another balloon experiment dealing with microgravity in a falling capsule which has already been of practical use.

IV. LAUNCH VEHICLES

In the wake of the successful trial of the CZ-2E launch vehicle, the CZ-3A launch vehicle will soon be tested. This launch vehicle can put a spacecraft weighing up to 2.5 tons into synchronous-transfer orbit.

China is currently studying ways of reducing debris production during the launching process which will first be applied to launch vehicles. Researchers in this field are currently discussing the matter and cooperating with their United States counterparts.

V. SPIN-OFF BENEFITS OF SPACE TECHNOLOGY

China's policy encourages and supports the extension of the products of high technology to other areas. The control, remote sensing, information, cryogenic, optics and radio technologies developed as part of space technology have already begun to revolutionize industry, agriculture, medicine and other fields, with positive results. Examples of this are standard main-line industrial control mechanisms, the use of X-ray imaging systems in medicine, infrared railway thermal axle controls and floating data collection devices for use in oilfields and at sea. In addition, error-tolerant self-adapting control systems and computers for automating measurement and control systems are already in use in oil refineries, waterworks, breweries, power stations, etc.

Gyroscope and platform technologies can be used in other areas, such as the railway sector, where rail unevenness can now be measured with much greater speed and accuracy.

Heat pipe technology, used in satellite thermal controls, has led to the development of heat exchangers, black bodies, thermostats and solar collectors, and already has many applications in the electronics, instrument-making, textile, chemical, casting, boiler-making and other industries as well as in everyday life.

Ion-etching is an ultra-precision technology developed from space-materials processing. Ionic beams are used to bombard solid surfaces; the sputtering effect produced creates geometric patterns. This technology is already being used in micro-processing in the electronics, chemical and instrument sectors.

The micro-crystalline glass materials used in space which can withstand high temperatures, resist ablation and have excellent electromagnetic properties, are widely used in microwave oven cases and electromagnetic stove tops. They are already used as the substrate material for microwave electronic equipment and as the outer covering for atomic frequency standards.

The magnetic coupling and drive technology used in vacuum simulation experiments in space is increasingly employed in the petroleum, chemical, atomic energy and foodstuff sectors because of the impermeability of the seals used in vacuums and high-pressure containers.

In addition, the materials developed in the early stages of space technology - insulation, protective materials, solar batteries and nickel-cadmium batteries, etc. - have become common in many sectors and in daily life because of their outstanding properties.

VI. INTERNATIONAL COOPERATION

China has established a national preparatory committee for International Space Year and has participated in activities relating to the Year. A meeting of the Panel of Experts on Earth Science and Technology for International Space Year will be held in February 1992 at Beijing.

In April 1990, AsiaSat-1 was launched from the Xichang launching site via the CZ-3 launch vehicle. It is a communications satellite developed by the Hughes Corporation of the United States. In July 1990 a model satellite (based on the Australian Aussat-B satellite) and the first Badr-A satellite developed by Pakistan were launched from the Xichang launching site via the CZ-2E launch vehicle. In 1987 and 1988, China used recoverable remote-sensing satellites to conduct microgravity experiments for France and the Federal Republic of Germany.

In March-April 1992, the CZ-2E launch vehicle will be deployed at the Xichang launching site to launch a communications satellite developed for Australia by a United States company. During the latter part of the year, another Australian communications satellite is to be launched. In August 1991, a CZ-2C launch vehicle will launch a Chinese recoverable remote-sensing satellite from the Jiuyuan launching site which will also carry the Swedish scientific satellite Freja, developed by the Swedish Space Corporation and weighing 230 kg.

In 1988, the Governments of China and Brazil approved a plan for the joint development of an Earth resource remote-sensing satellite (CBERS). Technical personnel from China and Brazil are currently working on the plan. China and Brazil are both third world countries, and such cooperation has far-reaching implications for global development of the space industry. It is to be hoped that this initial cooperative effort between developing countries in the area of space technology will be successful.

The Chinese Academy of Sciences and the State Bureau of Seismology are cooperating in the development of the third-generation man-made satellite laser range-finder; they participated in the NASA laser tracking network and in the tracking of the United States LAGEOS satellite, France's Starlette, Japan's Ajsal and the Soviet Etalon-1 and Etalon-2.

From 23 to 27 September 1991, the Chinese Government and the Outer Space Affairs Division of the United Nations and the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) jointly conducted a regional workshop on the application of space techniques to combat natural disasters. Participants included Afghanistan, Bangladesh, France, Indonesia, Italy, Japan, the Lao People's Democratic Republic, Malaysia, Mongolia, Myanmar, the Netherlands, Pakistan, the Philippines, Spain, Sri Lanka, Thailand, the United Kingdom, the United States and Vanuatu, as well as 38 representatives of relevant United Nations organizations and 43 delegates from China. The meeting considered the uses of such technologies as remote sensing, satellite communications, etc., in natural disaster prevention,

forecasting and disaster rehabilitation and discussed questions such as the launching of international cooperation in this area. The conference was entirely successful.

In recent years, the Chinese Government has sought to strengthen international cooperation relating to space applications: China has cooperated with Bangladesh in using geographic information systems technology to conduct flood-control research; work has been done with Malaysia on the use of remote-sensing and geographical information systems to monitor tropical soil erosion; China has cooperated with Mongolia in the use of remote-sensing technology to explore grassland resources and with the United Kingdom in areas including remote-sensing geological surveys. All these cooperative efforts have progressed smoothly and all parties have cooperated in a fully satisfactory manner. China continues to provide training in the use and application of remote-sensing data for States in the Asian and Pacific region.

A portion of China's communications satellite programme is conducted in cooperation with German and French companies.

China maintains contacts and cooperates in various areas of space exploration and space technology with the Soviet Union and the United States of America.

COLOMBIA

[Original: Spanish]

Colombia does not at present have sufficient resources to offer cooperation and training on matters relating to outer space; on the other hand, as a developing country, it is able to benefit from the programmes presented by other countries.

Notwithstanding the above, Colombia has developed a domestic network of rural satellite telecommunications for telephone systems and television reception, with low-cost Earth stations, independently powered by solar energy, installed throughout the territory of Colombia; and it is hoped that a total of 43 Earth stations will have been installed by the end of 1991.

With the cooperation of the Government of Canada, a satellite disaster network has also been developed, initially comprising 15 Earth stations situated in high-risk areas, all information from which is gathered in a management centre at the headquarters of the Instituto Nacional de Investigaciones Geológicas y Mineras (National Institute for Geological and Mining Research).

CZECHOSLOVAKIA

[Original: English]

Space physics

From the scientific instruments of the Czechoslovak Magion 2 and Interkosmos 24 satellites, a unique set of data on wave phenomena and on the parameters of plasma in the outer ionosphere and the lower magnetosphere of the Earth were obtained. From this set of data the experimental characteristics of a new kind of plasmaspheric emissions were determined, allowing a new interpretation of the mechanism of their origin by the so-called fan-shaped instability. In the middle ranges of the lower plasmasphere unusual high concentrations of double ionized ions of oxygen and nitrogen were found. During the active service-life of the Magion 2 satellite (January-December 1990) its activity was controlled by the Czechoslovak telemetric station Panská Ves, which also received scientific data from both of the above-mentioned satellites of the "Active" project (Geophysical Institute of the Czechoslovak Academy of Sciences).

In the field of international cooperation, development work also continued on the flight-sample in the next Czechoslovak satellite of the Magion series, involving active plasma experiments of the "Apex" project, to be completed by the end of 1991 (Geophysical Institute of the Czechoslovak Academy of Sciences).

Further processing of data from the joint Czechoslovak-Soviet "Intershock" project and from the German sounding rocket "Helios" enabled the comparison of theoretical models of the shapes of magnetic clouds in the solar wind with the experimental data. The information obtained gave evidence supporting the spherical model (Astronomical Institute of the Czechoslovak Academy of Sciences; Athenian University of Athens, Greece).

The completion of the new model for distribution and variations of the total density of the upper atmosphere, which has yielded new knowledge regarding the theory of satellite movement, has resulted in the awarding of the prize of the Czechoslovak Academy of Sciences (Astronomical Institute of the Czechoslovak Academy of Sciences).

Space meteorology

Work continued on the development of methods for the reception, processing and implementation of measurements from the United States and West European meteorological satellites of the National Oceanic and Atmospheric Administration (NOAA) and Meteosat (Czech and Slovak Hydrometeorological Institutes).

During the course of research on the upper atmosphere within the framework of the international "DYANA" and "VOT" campaign, double measurements of the absorption of radio waves and of the phase height of the reflection in the lower ionosphere were carried out (Geophysical Institute of the Czechoslovak Academy of Sciences).

Space biology and medicine

The joint Czechoslovak-Soviet embryological experiment "Incubator" was carried out at the Mir orbital station and confirmed the normal prenatal development of the embryos of Japanese quail, including their hatching in the state of weightlessness. Preservation of their basic life functions during the two to four days of postnatal development was confirmed. The spatial orientation of the chicks was, however, affected. Specialized laboratories of the United States also joined in the evaluation of the biological samples (Institute of Animal Biochemistry and Genetics of the Czechoslovak Academy of Sciences).

Within the framework of investigations of the oxygen regime of mammals in the gravitation-less state using the Czechoslovak-made oxymeter INKT-01 in monkeys on board the Kosmos-2044 biosatellite preferential supply of oxygen to brain tissues was demonstrated (Biophysical Institute of the Czechoslovak Academy of Sciences).

Materials investigation of space

A set of experiments using the Czechoslovak programmable crystallizer ČSK-1 was carried out on the Mir orbital station. In the $PbCl_2$-AgCl multi-component eutectic mixture, an increased tendency to uneven solidification in the state of weightlessness has been observed.

A three-party space experiment (Czechoslovakia-Germany-USSR) aimed at the study of the undercooling of alloys in an amorphous mould was carried out (Institute of Physics of the Czechoslovak Academy of Sciences).

Remote sensing of the Earth

The development work continued on the optical-mechanical block of the infrared spectrometer Istok-1 for a multilateral ecological project entitled "Priroda" (Nature), which was included as part of International Space Year (ISY) (Institute of Physics of the Czechoslovak Academy of Sciences).

In order to ensure the participation of Czechoslovakia in international space projects, 145 specialists were sent abroad as delegates and 263 delegates were received from abroad in the country.

The scientific and technological level of our research centres in the field of space research enabled us to make use of the possibilities offered within the framework of the Pentagonal (a regional organization of five European countries) for establishing cooperation with the space agencies of

Italy and Austria. The first steps have been taken with a view to establishing new contacts between Czechoslovakia and the European Space Agency (ESA) and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), which reacted positively to Czechoslovakia's desire to establish contacts. Further, a five-year agreement on cooperation in the chosen fields of space research was concluded between the Czechoslovak Academy of Sciences and the French National Centre for Space Research (CNES) in September 1990.

FINLAND

[Original: English]

1. Introduction

The first Finnish space programme (1987) had a summary of recommendations for the period 1987-1992, including an overview of the general features and developments of Finnish space activities. From the end of the 1980s a considerable amount of new economic resources has been allocated to these activities in Finland. Emphasis has been on the development of space technology and on introduction of new applications. Finland has become an associate member of the European Space Agency (ESA) and has concluded an agreement on bilateral cooperation with the Soviet Union. Many new programmes, projects and other forms of international cooperation have been launched in the wake of these agreements.

On the basis of all this experience the Committee has considered it necessary to redefine the objectives and update the programme to cover the period until the end of 1996. By that time Finland is expected to have been a member of ESA for two years.

ESA membership is of great significance for the Finnish science and technology policy. Finland's associate membership in ESA since 1987 was a logical result of the new Finnish technology policy, as outlined in the early 1980s. One central element of that policy was an active participation in scientific and technological cooperation in Europe. The gradually increased participation in the ESA programmes and the development of technology and test facilities during the first half of the 1990s are intended to enable a high-standard Finnish contribution to international space cooperation, concentrating on areas in which Finland possesses an existing high level of competence and know-how.

In the current situation it appears that global cuts in financing may be necessary in space activities worldwide, particularly in the large-scale infrastructure programmes. In some cases this may lead to a reconsideration of the objectives and extensions of estimated time schedules.

1.1 Current space-related activities

Finnish space activities have proceeded in accordance with the guidelines laid down in the first space programme. The rather modest development measures have been focused on areas where the activities can be expected to yield the maximum scientific and technological benefit.

Space science

Finland has since the beginning of 1990 contributed as full a share of its gross national product (GNP) to the ESA science programme as the other member States. Finnish research teams are engaged in 18 satellite projects, 6 of which belong to the instrument projects of the ESA science programme and 12 to bilateral projects (9 of which are included in cooperation projects with the Soviet Union). The activities are primarily concerned with solar and magnetospheric research, but projects within radio and X-ray astronomy and Martian metrology are included as well. Finnish scientists have done earlier work in this field, but these new projects will increase the activities many times over. A total of 11 new projects is planned.

Satellite telecommunications

Within the ESA telecommunication programme, Finland participates in the advanced systems and technology programme, the payload and spacecraft development and experimentation programme for developing satellite telecommunications, the Apollo/Diana data distribution programme for Africa, and the data relaying satellite system infrastructure programme for data communication. Finnish industry and research institutes have participated actively in these research and technology programmes.

Earth observation and satellite geodesy

Finland participates in the Earth Observation Preparatory Programme (EOPP), where future Earth observation programmes are prepared for ESA. Feasibility studies for ESA have been carried out within this programme. In addition, a bilateral instrumentation project for ozone monitoring in the atmosphere, called GOMOS (Global ozone monitoring orbital system), has been launched. The instrument is proposed to be included in the payload of ESA's first polar platform satellite, POEM-1. Finland participates in two research projects within the ESA ERS programme.

Earth observation technology for winter navigation has been developed mainly in cooperation with Sweden and the Soviet Union. The global positioning system (GPS) satellite system is used for navigational and positioning purposes. It is obvious that the importance of this system will increase further in the future. This has already lead to considerable savings, especially in the positioning services needed in cartography.

Basic technologies

The technology needed for space equipment has been developed mainly in connection with the construction of instruments for scientific projects. As a result, the capability for quality control, testing and assembly has improved considerably during the last few years.

1.2 Motives behind space activities

The national motives for entering into and promoting space activities are connected with the development of scientific and technological skills and the achievement of social goals.

The scientific motive is the desire to understand the structure and development of the globe, near-Earth space and the entire universe, as well as the behaviour of matter in extreme conditions. Through the ESA membership and the bilateral projects, Finnish scientists have good chances of arriving at new and more comprehensive research results in this field. Basic sciences also create prerequisites for technological development. In addition, the scientific space research exerts a considerable positive influence on education and training and raises the general level of knowledge.

The technological motives are ultimately based on a constantly increasing need for internationalization and especially on the participation of Finnish industry in the research and development cooperation of Western Europe. The ESA technology projects have connections with the cooperative ventures within Eureka and the European Community (EC). In addition to aspects related to transfer of technology, it is very important for Finnish technology and business to become known in the large market area of Western Europe. Internationalization of technological development is essential, even for general European competitiveness on the world market. Further important considerations include the ability to modernize existing industries and the creation of an infrastructure for establishing new industries.

Motives related to national and community development are connected with the need to collect information on natural resources, weather conditions, traffic facilities, land use and environmental conditions and to meet the telecommunication requirements of modern society. Though some of these needs can be satisfied through other international organizations, space cooperation is unique in getting virtually real-time data and for introducing new means of data retrieval. Earth observation technology is often more efficient and economical than the traditional information collection methods, and is therefore competitive in many applications. A full-scale utilization also necessitates a continuous development of instruments and analytical methods. In addition, the space projects are an excellent way of creating an extensive culture of cooperation.

The current space programme outlines the objectives and measures intended to contribute, on the basis of the above-mentioned motives, to a framework for the Finnish space activities during the period 1991-1996, as well as to the organization and the funding needed for those activities. It does not cover the activities within the International Telecommunication Satellite Organization (INTELSAT), the International Maritime Satellite Organization (INMARSAT) and the European Telecommunications Satellite Organization (EUTELSAT). The costs of using their operational services are paid by the users.

2. Objectives

The objectives of the Finnish space activities for the planning period are as follows:

1. To make an economic, scientific and technological contribution to the development of European space activities, especially within the European Space Agency;

2. To raise both quantitatively and qualitatively the standard of Finnish space science and to promote the opportunities for Finnish scientists to participate in international space cooperation;

3. To develop Earth observation activities in nationally important areas, in particular to safeguard continuous access to data, and to promote technologies and applications;

4. To raise Finnish space technology to the European level and to improve the preconditions for commercial and industrial activities in selected areas;

5. To increase and internationalize education and training for space research and to intensify national administrative cooperation in the space sector in Finland.

In addition, the opportunities offered in other areas (e.g., microgravity and rocket technology) should be further evaluated. Very extensive follow-up projects cannot be included in the financial envelope of this programme. However, if necessary, additional fundings may be considered on the basis of the further studies conducted during the planning period.

2.1 Finnish space activities as part of European cooperation

European space cooperation has grown out of and developed from the need to create a capability in Europe to meet the global competition, in particular with regard to applications of space technology. In this field the countries outside Europe are clearly ahead of any individual European country. The drastic increase in the economic and technological cooperation in Western Europe during the past decade can be largely understood against this background.

Participation in cooperation that supports a harmonious development in Europe is also beneficial to Finland. The cooperation in space activities as part of the whole field of scientific and technological cooperation aims at improving European capabilities and thus supports the economic, scientific and technological competitiveness of our continent.

From the Finnish point of view, international cooperation should be based on a balance between interests and contributions. The cooperation has to be reciprocal and beneficial to all participants.

2.2 Quality of scientific research

The most important science policy objective in space science is to demonstrate the significance of Finnish space research within the international community and to provide opportunities for participating in new projects.

One objective of scientific research is to attain the highest international level in such areas where experience and know-how has been gained and where research is sensible with regard to the prevailing general stage of scientific and technological development. Another important objective is the transfer of the technological knowledge obtained in the projects into industrial use.

Near-Earth (space plasma physics) research aims to gain an understanding of those energy transfer processes in the Sun-Earth system which are caused by the solar wind and where the dynamics of the magnetosphere play an important role. The exploration of other planets and plasma processes of the whole solar system is one element in the overall research pertaining to the solar system.

Solar system research focuses on the characteristics of the Martian atmosphere and the origin of its moons, the properties of the solar wind and investigation of Saturn and its moon Titan.

Space astronomy has the task of collecting new information on distant objects in space by combining results from studies on radio waves and observations made at X-ray, gamma and ultraviolet wavelengths. A further aim is scientific utilization of the infrared measurements made by the Infrared Space Observatory (ISO) satellite and the optical measurements made with the Hubble space telescope.

Preparations for an active participation in the third cornerstone programme of ESA will be made. ESA has not yet finalized the programme, where either a space telescope for the submillimeter area (FIRST) or a planetary probe to study the nuclei of comets (Rosetta) will be realized.

2.3 Remote sensing

Earth observation provides an effective method for gathering information on our environment and its various elements. The most important areas of applications of remote sensing are environmental protection, natural resources survey, meterological services and cartography.

Access to and distribution of data will be improved so that the users can obtain their observation data as quickly as possible. This calls for virtually real-time access to data, elaborated methods for data transfer and increasingly efficient archiving.

In order to introduce new methods, instruments and devices are designed for satellites or aeroplane applications. Also, methods will be eveloped for testing and calibration of detectors and for analysis of the procured data.

Regarding the applications, the efforts are to be concentrated on the most important areas for society:

- Ensuring real-time access to remote-sensing data for climatic research, meteorological services and environmental monitoring;

- Improving the utilization of Earth observation for environmental objectives, for operation and monitoring of the quantity and quality of water and for waterway transport;

- Designing data systems to speed up forest inventory, processing data from increasingly smaller forest areas and for producing as versatile information as possible about the condition of the forest ecosystems;

- Evolving methods for the supply and distribution of geological data furthering the economic use of natural resources for the purposes of industry and commerce, land-use planning and environmental protection;

- Creating improved methods for the investigation and evaluation of the environmental effects on the community;

- Developing better methods for fast updating of maps, for the use of digital information in positioning data systems and for the needs of satellite geodesy.

2.4 Promotion of space industry and technology

A target for the next few years is to develop technologies to improve the competitiveness of Finnish industry within the ground segment area of space applications, and of the telecommunications sector in particular, and to create technological preconditions for successful industrial activities in certain sectors of the space segment.

All available efforts should be undertaken to increase the industrial return from ESA. The agreement on associate membership in ESA does not guarantee an industrial return to Finland. The objective is however to attain a level of 80 per cent (approximately 50 million markkaa) of the calculated maximum return by the year 1995.

In order to get orders from ESA a member country has to respond to the invitations from ESA to tender competitive bids. Making a tender is, even for small contracts, a strenuous and costly task, especially for small companies. During the current planning period measures will be taken to ensure that tendering is not called off for this reason.

National capabilities and transfer of technology will be developed as follows:

- Subcontracting to Finnish industry will be increased in the equipment development projects of the research institutes;

- The Technical Research Centre of Finland will create capabilities for competitive environmental testing and integration of space equipment;

- To promote transfer of technology, a sufficient number of Finns should be employed in the administrative bodies and research institutes of ESA and possibly in space projects of the United States of America;

- Industry and research institutes will cooperate to develop and demonstrate their capabilities for technologically justified bilateral cooperation projects.

2.5 Education, training and organization

The main objective in developing the education of, training for and organization of the space activities is to support the above-mentioned national targets by channelling increased staff resources to these activities, in proportion to their extent, by ensuring the continuity of the project work and by intensifying the contacts between the parties in the Finnish Space Committee. A more detailed account of these plans is given in sections 4 and 5 below.

3. Measures

The measures necessary to achieve the above-mentioned objectives and to enable the development of a clear-cut long-term strategy can be grouped as follows:

1. Negotiations with the European Space Agency;

2. Space science;

3. Earth observation and satellite geodesy;

4. Satellite telecommunications;

5. Basic technologies;

6. Other programmes.

The measures related to education and training and to the organization are set out in sections 4 and 5 below. Execution of the programme requires a gradual increase of funding and an appropriate allocation.

3.1 Negotiations with the European Space Agency

The extent of the Finnish space activities is decisively dependent on Finland's relations to the European Space Agency. An associate member can participate in decision-making only in regard to those programmes to which that member contributes. The rules of ESA guarantee industrial return to members only. The member countries can participate in all optional programmes, and industrial return is guaranteed to the members. The industrial return promotes the utilization of the appropriations granted to the Agency in a manner significant to the member country. This requires, however, the evolution of the industrial capabilities, in order to enable industry to make use of the return.

To ensure full benefit from its cooperation as an ESA member the Finnish staff resources must be increased in the space sector. Preparation for the challenges entailed by its membership also require continuation of its present associate membership status. A proposal on this has already been submitted to ESA. At the same time preparations are being made for negotiations with ESA concerning full membership.

3.2 Space science

At present, the equipment construction related to space science is financed by the Technology Development Centre (TEKES), where research and development on new technology is involved, and by the Academy of Finland for scientific objectives. The contributions by the universities of technology and the research institutes themselves are of great significance. With regard to technological and industrial development, the share of the research equipment projects in the Finnish space activities is considered adequate.

If the total volume of research activities is further increased, it must be financed by the appropriations of the universities of technology, the research institutes and the Academy. For this reason a new principle is proposed: all regular activities should be financed by the sectors themselves (Finnish Meteorological Institute, Technical Research Centre of Finland, etc.). New activities will be started as projects supported by the Academy of Finland. For improved efficiency the resources for space research in the universities should be increased by special measures of the Ministry of Education and the appropriations for space research at research institutes outside the universities should be increased.

During the current planning period the expenditure in real terms for the research activities will be increased by approximately 10 per cent per year. The research will be directed in such a way that in 1996 approximately 50 per cent of the resources are allocated to the programmes carried out within ESA and approximately 40 per cent to national, bilateral and multilateral projects. About 10 per cent of the research funds will be reserved for the preparation of new scientific programmes. Attempts will be made to extend the temporary employment of the scientists working in the research projects and to create new posts at universities and other research institutes. In scientific space projects, a maximum technological benefit will be sought by submission of as many of the equipment subcontracts as possible to Finnish industry.

Examples are given below of projects in which Finland participates or which are already the subject of negotiation.

In research on near-Earth space the ongoing projects related to the ESA cluster programme, the Soviet Interball programme, the Swedish-German Freja Satellite and the Polar Programme of the National Aeronautics and Space Administration (NASA) (United States) will be carried out. At the same time, the possibilities of participating in any forthcoming new international project are being studied.

In research relating to the solar system Finland will engage in the Soviet Mars-94 programme through the METEGG (Martian meteorology) Project to explore the Martian atmosphere. If possible, Finland will engage in the ESA Marsnet programme and follow the progress of the plans for other Mars missions.

During the programme period two Finnish projects (ERNE and SWAN) related to the SOHO Programme of ESA for solar research will be carried out. Finland will contribute to the joint Cassini-Huygens programme of ESA and NASA.

In space astronony Finnish projects related to two Soviet satellites (Radioastron and Spectrum-X-Gamma) will be carried out and Finland will also consider participation in the Spectrum-A programme).

Finland will engage in the ESA space telescope programmes ISO and Horizon 2000, and the Hubble space telescope programme of NASA as a user of

scientific data. Plans are being made for a Finnish contribution to the forthcoming third cornerstone programme of ESA, which will be either Rosetta or FIRST.

In all these subsectors of space science research, preparations have to be made for contributions to programmes that are to be agreed upon during or after the current planning period.

3.3 Earth observation and satellite geodesy

To expedite the supply and distribution of data, Finland will participate in the ESA Earth observation programmes Earthnet, ERS-2 and POEM and will study the possibilities of participating in the Aristoteles cooperative research project. In the area of Soviet cooperation, real-time observation data will be acquired to assist wintertime navigation.

The satellite Earth station of the Finnish Meteorological Institute will be enhanced for receiving real-time data from the new Earth observation satellites (ERS-2 and POEM of ESA and the Soviet satellites Meteor and Kosmos). In satellite geodesy the Metsähovi Research Station will be developed to serve as a reference point for the GPS system. For the development of the data transfer methods, specific projects will be launched to speed up the distribution of the observation data for use in wintertime navigation and on board research vessels, and from the Finnish Meteorological Institute (FMI) further to the users. The data archiving systems will be elaborated in terms of the ESA Earthnet programme.

To ensure access to remote-sensing data the need for a Finnish satellite receiving station meeting international requirements will be studied. The best site location would be in Sodankylä, where the required infrastructure already exists and space research activities are carried out.

For technological developments, national projects pertaining to radar and instrument technology will be started. The basis for support to this sector is the vital importance of Earth observation to environmental monitoring and inventory of natural resources. In the long term, radar and instrument technologies can create new domestic industry. To demonstrate the Finnish know-how in instrumentation, Finland will engage in international measurement campaigns within the EOPP Programme of ESA or some bilateral projects.

Key technologies for remote sensing are image interpretation and processing of SAR data. In addition to the above-mentioned programmes, the possibilities of using data from the Canadian Radarsat project are being studied. In Earth observation projects, particular emphasis is laid on participation of the users in research and development.

As for applications, Finland will participate in the design of a spectrometer for atmospheric ozone measurements (GOMOS) and further in the activities of EUMETSET. The ESA ERS-1 programme will provide information on

Earth observation data relating to water resources and waterways transport. International measurement campaigns for forest inventory will be attended, and projects for providing geological data will be launched. In the field of satellite geodesy, Finland will engage in defining geoids by means of altimetric measurements in the Baltic and Mediterranean areas and prepare for participation in the Aristoteles programme.

3.4 Satellite telecommunications

During the current planning period Finland will engage in the ESA telecommunications programmes ASTP, PSDE, DRS and Apollo/Diana and will make preparations for participation in new ESA programmes in proportion to the industrial interests in Finland.

The prerequisites for industry in the field of satellite telecommunications will be improved by the launching of national projects. The projects will pertain to DBS television and cable television, mobile telecommunications, microterminals (VSAT), special Earth stations, navigation and positioning. Competitiveness in both the ground segment procurements of ESA and in the free world market is the goal.

The capability of Finnish industry for the delivery of payloads to telecommunications satellites is considerably lower than the capability in the ground segment. For this reason any available resources should be allocated to new technologies, mainly digital signal processing, software technologies, millimeter-wave technologies and optical intersatellite telecommunications.

Particular emphasis is to be laid on the synergism generated by the space projects to other business areas of the companies, and to the links of these projects to the Eureka and EC telecommunication projects.

3.5 Basic technologies

Finland is engaged as a subcontractor in deliveries of instruments for satellite platforms within the ESA Science programme (Horizon 2000). This subcontracting makes a more general utilization of space and participation in future space infrastructure projects possible. Subcontracting for deliveries of control stations within ESA is also being planned.

During the programme period 1991-1996, national projects will be launched for the purpose of creating capacity for deliveries of payload hardware and instruments for satellite platforms on carefully selected subsectors of technology. Particular attention will be paid to determination of the optimal procedure for delivering industrially useful aerospace equipment with regard to membership in ESA and continuity of space activities. The development of minisatellite technology will be followed. Opportunities of contributing to a minisatellite project in Nordic or other bilateral cooperation will be studied.

3.6 Other programmes

An investigation of the opportunities for research in the field of microgravity for Finnish research and industry is being carried out. Further developments in and contributions to this area depend on the results of this investigation.

Attempts are being made world wide to reduce considerably the current costs of satellite launching. The opportunities for long-term involvement in new rocket technology projects will be investigated with the view to specialization at the component level. Further development in and contributions to this area will largely depend on the preconditions for operation and the activity of the industry.

4. Education and training

Space-related university education is provided in astronomy, physics, space technology, telecommunication technology and geodesy. Astronomy can be studied at the institutes of astronomy of the universities of Helsinki, Oulu and Turku, and in a smaller scale at the Helsinki University of Technology. The educational schemes for physics (the universities of Helsinki, Turku and Oulu) provide space-related education, including physics of cosmic radiation and space plasma physics. Courses on remote sensing are included in some educational schemes as part of the subject studies in each area of applications. The Helsinki University of Technology provides education in all subjects related to remote-sensing technology. Comprehensive education in geodesy is given at the University of Helsinki.

At the Helsinki University of Technology it is possible to specialize in space technology (since 1987 in the educational scheme for electrical engineering) and remote sensing (since 1986 in the educational scheme for geodesy). The annual number of students at the Institute of Space Technology of the Helsinki University of Technology is 25 to 45, of which about 10 will choose a subject related to remote-sensing or space technology for their engineering diploma (M.Sc.) thesis.

The education and training relating to space activities should not be considered separate from other techno-scientific or scientific education. Degrees of licentiate and doctor of space physics are being planned also for postgraduate students with a basic degree in, e.g., physics, theoretical physics, technical physics, electrical engineering or astronomy. Such an arrangement would relieve the shortage of researchers in space science during the next few years. Further education of industrial staff working with space research and development will be evolved on the basis of QD studies (studies for a diploma of qualification) in cooperation between the universities.

An important contribution to the space-related education and training are the special courses in this field and, for example, summer courses and summer schools intended for both researchers working at universities and those

employed in industry. The International Space University (ISU) organizes a comprehensive course of two months every year. Furthermore, the Nordic community has arranged some space courses, and more activities are being prepared within the cooperative body of scientists, the Nordic Society for Space Research (NSSR). It is in the interest of the education of the Finnish space scientists to support these course arrangements.

The continuing education in this field is partly organized at research institutes outside the universities and also in the form of training for research staff in the industry. The Finnish Meteorological Institute in particular has trained many scientists, and in recent years this training has been increased. Scientists preparing for postgraduate degrees are employed at the Geophysical Observatory in Sodankylä as well.

Development of the continuing education should not be the responsibility of active research teams and institutes alone. Instead, the universities should allocate more educational resources to space research and to arrangements for foreign scientists and teachers to work in Finland for one year or more. A good example of this is the University of Oulu, where at the moment an invited scientist from the Max Planck Institute, Germany, provisionally holds a professorship in space research and technology. In addition to improving space-related education in Finland, the opportunities for Finns to study abroad should also be improved. Nearly all postgraduate students should have the opportunity of working for at least some months with some foreign research team when writing their doctor's theses. Further, postdoctoral education in space science should be developed in cooperation between the universities and the financial research institutions. The positions of junior researchers offered by the Academy of Finland can also serve the postdoctoral education of young scientists in this field.

The space research education introduced by the Academy of Finland in 1990 is aimed at contributing to an increase of the space research resources. In 1990 the Research Council for the Natural Sciences allocated 600,000 Fmk for this education, and an equal sum was budgeted for 1991. The Research Council for Technology allocated 400,000 Fmk for this education in 1990, and the appropriation for 1991 is 500,000 Fmk. In addition, both research councils support the education of space scientists also by setting up provisional researcher's posts in this field, and especially by allocating funds to employment in space research projects for continuing education of research assistants.

At present about 30 scientists are engaged in space research in Finland, some of them only part-time. In order for Finland to reach the European level, the number of space scientists should be increased to 50-60 persons by the end of the present decade.

5. Organization

The following ministries are responsible for the development of Finnish space activities: Ministry of Trade and Industry (technology and industrial policy, ESA); Ministry of Education (research and education policy); Ministry for Foreign Affairs (general international conditions); Ministry of Transport and Communications (operational satellite telecommunications, meteorology and Earth observation); Ministry of Agriculture and Forestry (Earth observation, satellite geodesy); and Ministry of the Environment (environmental monitoring). The coordination and further planning of the space activities are the responsibility of the Finnish Space Committee set up by the Government. The Committee is a consultative body and works in connection with the Ministry of Trade and Industry.

The Academy of Finland funds the scientific projects and the space-related education. The Technology Development Centre funds the projects for technological research and product development and the majority of the programme contributions to ESA, as these costs mainly pertain to industrial activities. A considerable part of the scientific research, the equipment construction and the application of the space activities is financed through various institutes by direct sector funding from the ministry governing that administration sector.

The International Development Agency of the Ministry for Foreign Affairs funds one of the ESA programmes (Apollo/Diana).

The space activities are carried out by industry, universities and research institutes, which are expected to cooperate in terms of the projects. The universities and the research institutes are particularly responsible for the scientific research of the discipline in question, but also for equipment development in cooperation with manufacturers. The role of industry in instrument development should be extended gradually. The financing bodies decide on the projects to be carried out and inform the Finnish Space Committee on the progress of the work. At the end of the current planning period the Finnish Space Committee will evaluate the outcome of the activities.

In practice, all parties involved in the work are jointly responsible for the international contacts. Finland is officially represented in ESA by the Finnish delegates to the ESA Council and the bodies working under the Council. In the projects with the Soviet Union, Finland is officially represented by the Space Working Group of the Scientific and Technology Committee working in connection with the Ministry for Foreign Affairs. Proposals for designation of the delegates are made by the Finnish Space Committee, and the delegates are designated by the relevant ministries and sector authorities.

During the current planning period, no major organizational reforms are necessary. Instead, the administration will be made more efficient by an elaboration and strengthening of the existing decentralized model. This is

above all aimed at linking the activities to the general scientific and technological policy, improving the contacts between the various parties involved and providing a more clear-cut overall picture of the activities.

Expansion of the space activities calls for expansion of the activities of the Finnish Space Committee as well. It is proposed that two project managers should be appointed to the Finnish Space Committee, in addition to the Secretary-General. One of the project managers should be appointed immediately and the other in the middle of the programme period. This measure is aimed at improving the follow-up of planning and coordination of the space activities and improving the flow of information to all parties concerned. The Finnish Space Committee should be provided with sufficient resources, e.g., funds for expenses resulting from the international activities. Such activities include the involvement of specialists in the events of the International Space Year 1992 and in the various bodies and committees of ESA.

INDIA

[Original: English]

The Indian Space Programme, organized under the Department of Space, Government of India, is dedicated to the peaceful uses of outer space and aims at the self-reliant development of space technology and its applications for the rapid socio-economic development of the country. The programme also aims to promote appropriate international cooperation and includes scientific exploration through outer space as one of its components. The activities under the programme cover the development of space systems, including satellites and launchers, and the operation of these systems to derive benefits in the areas of communication, broadcasting, education, meteorology and the management of national natural resources. An overview of progress achieved in 1990-1991 under various segments of the programme as well as aspects relating to international cooperation are presented in the following sections.

Indian remote-sensing satellite series (IRS-1A and IRS-1B)

IRS-1A, the first in the series of indigenous operation remote-sensing satellites, completed three years of successful operation (thereby reaching its design-goal) during March 1991 and has been continuing to provide space-based remote-sensing data. The second satellite in this series, IRS-1B, whose purpose is to continue the functions of IRS-1A, was successfully launched on 29 August 1991 on board the Soviet Vostok rocket. The satellite has since been declared operational after its successful completion of the early phase operations. The satellite weighs 990 kg and, like its predecessor, carries two cameras, an LISS-I and an LISS-II, with resolutions of 73 metres and 36.5 metres respectively for imaging the Earth surface with a swath width of 148 km.

The data from the IRS-1A satellite has been the mainstay of the National Natural Resources Management System. The applications extend over a number of areas such as land use/land cover mapping, agro-climatic planning, wasteland mapping, integrated land and water resources study for combating drought, crop acreage and yield estimation, forest mapping, etc. Several new applications projects have also been initiated. For the first time, hydro-geomorphological mapping of the entire country, covering 447 administrative districts, has been completed, showing groundwater potential using satellite and conventional data under a project for the National Drinking Water Mission.

Further satellites planned in this series, viz., IRS-1C and 1D, are under construction; these satellites are planned to have improved spectral and spatial resolutions, revisits, stereo-viewing and on-board video data recording capabilities. To promote international cooperation, India announced the availability of data from IRS satellites to other countries, including facilities to access through setting up or augmentation of ground systems by the receiving country.

INSAT-I

INSAT-ID, the last of the first-generation INSAT-I series of satellites, was successfully launched on 12 June 1990 on board a Delta rocket from the United States. After a series of orbit raising manoeuvres and check-out operations from the master control facility in India, the satellite was commissioned in July 1990. INSAT-ID has been operating satisfactorily since then and the services from the earlier operational satellite INSAT-IB have been transferred to INSAT-ID. The INSAT system had been providing operational services for domestic telecommunications, meteorological observations, television and radio networking. INSAT has been serving 4,366 two-way voice or equivalent circuits over 120 routes. About 105 Earth stations have been serving under the INSAT telecommunications network, excluding some 450 micro-terminals which are used for National Informatics Centres computer networking. Until September 1990, INSAT-IB provided 30,826 meteorological images. In addition, INSAT supports the meteorological data relay services. The 0600-hours GMT VHRR image-derived wind data are regularly put on the GTS of the World Meteorological Organization (WMO). The 0300-hours GMT full-disc infrared pictures are being transmitted as radio facsimile broadcasts every day for reception in the neighbouring countries. In the area of providing nationwide television hook-ups, over 500 television receive/broadcast terminals participate and about 100 radio stations are in the INSAT network. In addition, about 35,000 direct reception terminals for satellite television are in use. Several new application services are under various stages of implementation. These include the Rural Telegraphy Network, the Remote Area Business Message Network, captive businesss terminal service, etc. The Disaster Warning System Service operated by INSAT through some 100 receiver terminals in the cyclone-prone eastern coast of India has been extensively used and proved to be very helpful during the cyclones that hit the eastern coast during May 1990. Efforts to develop a satellite news-gathering service in the CxS-band and the CxC-band using ultra-portable vehicle mounted terminals for TV/radio has been initiated.

INSAT-II TS

INSAT-II satellites are being indigenously fabricated to replace the foreign-procured INSAT-I series of satellites. The INSAT-II space segment is planned to comprise three spacecraft, with two of them collocated. INSAT-II satellites will have enhanced capabilities as compared to INSAT-I. Each of these will carry 18 FSS transponders operating in C-band/extended C-bands and 2 high-power transponders operating in the S-band for broadcast services. A two-channel VHRR will also carry resolutions for meteorological applications. INSAT-II will also carry a pay-load for satellite-based search and rescue. This payload will provide instantaneous alert capability in the region and is an important contribution to the international satellite-aided search and rescue programme. The first INSAT-II test spacecraft (INSAT-IIA) is scheduled for launch during early 1992 and the second spacecraft, INSAT-IIB, is planned to be launched a year thereafter by the European Ariane launch vehicle. During the year, the fabrication and assembly of the flight version of the spacecraft had progressed satisfactorily.

Augmented satellite launch vehicle (ASLV)

ASLV is designed to provide a low-cost vehicle to launch a 150-kg class satellite into low Earth orbit and to validate advanced technologies for the future launch vehicles. Though the first two development flights conducted in 1987 and 1988 were not successful, they provided valuable design inputs in the areas of strap-on technology, strap-on separation, inertial navigation technology, structure-control interaction, trans-sonic buffeting, acoustic levels, S-band TTC, metallic bulbous heat shield, etc.

All modifications based on the results of failure analysis of the earlier flights have been incorporated for the third developmental flight of ASLV planned during 1991-1992.

Stretched Rohini satellite series (SROSS)

The SROSS satellites are designed as payloads in ASLV launchers for low-cost/light-weight missions for scientific and technology experiments. SROSS-C satellites to be launched onboard ASLV-D3 will carry payloads for astronomy and aeronomy studies. These include a gamma ray burst detector and a retarding potential analyser instrument.

Polar satellite launch vehicle (PSLV)

PSLV is being built to launch 1,000-kg class remote-sensing payloads into a 900-km polar sun-synchronous orbit. The 275-ton, 44-metres-tall PSLV has four stages. The first stage is a 2.8 m diameter, 125-ton solid propellant motor with six SLV-3 first-stage motors strapped onto it. The 2.8 m diameter second stage with a liquid propellant motor carries 37.5 tons of fuel. The third stage is a 7-ton solid-propellant motor and the fourth stage is again a liquid propellant motor with 1.8 tons of fuel. PSLV incorporates closed-loop guidance with an onboard processor.

Several qualifications tests on the PSLV systems have been conducted during the year. The mobile service tower for the vehicle assembly at SHAR Centre (launch site in India) has been erected. The first developmental test flight of PSLV is planned during 1991-1992.

Geo-synchronous satellite launch vehicle (GSLV)

The configuration of a geo-synchronous launch vehicle capable of placing 2,500 kg class satellites into geo-synchronous transfer orbit (GTO) has been finalized and the development has been initiated to make it possible to meet the launch needs of geo-stationary communication spacecraft. In addition to the use of existing or proven stages of the current series of launch vehicles, the GSLVs will employ a cryogenic upper stage in order to provide for appropriate payload capability in GTO.

National Natural Resources Management System (NNRMS)

The National Natural Resources Management System in India has been established with the participation of various State and central government agencies. The Department of Space is the nodal agency for NNRMS. Several new remote-sensing application projects have been initiated under NNRMS during the year. These cover a wide spectrum of studies related to land use, drought monitoring, soil mapping, forest classification, wildlife habitat, mapping of grasslands, fisheries development, flood mapping, snow mapping, monitoring of wastelands and several studies related to the coastal environment.

The five regional remote-sensing service centres and 21 state centres in India have been undertaking remote-sensing application services, which extensively use satellite-based data. Several among these have also been contributing to the training and human resource development in this field.

Microwave remote-sensing programme

The development of an airborne synthetic aperture radar (SAR) has made further progress during the year. A full-scale development model of the SAR antenna has been successfully demonstrated. The dissemination of SAR data acquired using the X-band SAR system has been completed. The data reception centre of the National Remote Sensing Agency (NRSA) has been augmented for receiving the SAR data from the European ERS-1 satellite under an agreement with ESA, and several application experiments are planned which are relevant for agriculture, meteorological studies, etc.

Space sciences

The pursuit of activities in space sciences has continued in several institutions in India. The major activities included coordinated polarimetric observations of the comet Austin, a campaign to study the characteristics of the waves in the tropical middle atmosphere using rockets and balloons, a study of the measurement of ozone and other trace gases using a balloon-based cryogenic air sampler (in collaboration with the Max Planck Institute for

Aeronomy in Germany), a study of the equatorial ionosphere through sounding rocket-based instruments, etc. A geosphere-biosphere study programme was initiated and studies are being undertaken for climate modelling, measurement of atmospheric minor constituents and aerosols, and the study of land-air-ocean interactions through balloon and space-based experiments. A national facility for stratosphere and troposphere studies using radar was brought into operation. This facility is dedicated to atmospheric studies and is expected to attain the capability for studying the mesosphere during the coming year. The National Advisory Council for Space Sciences has considered new initiatives to pursue studies in microgravity, popularization of space science and the study of the origin of life, etc. The studies on solar activity, composition of solar nebula, etc., continued through ground-based observations.

International cooperation

India continued to pursue and promote cooperation with several national space agencies in addition to contributing to the programmes and activities of international organizations, including the bodies of the United Nations and its specialized agencies, in the activities related to the exploration and peaceful uses of outer space. In cooperation with the Outer Space Affairs Division of the United Nations and the European Space Agency and as a contribution to the United Nations Space Applications Programme, India hosted and co-sponsored a special workshop in India on "Basic Space Science Research for Developing Countries". India also continued to participate actively in the Regional Remote Sensing Programme (RRSP) under the auspices of the United Nations Development Programme (UNDP) and the Economic and Social Commission for Asia and the Pacific (ESCAP). The eighth session of the intergovernmental committee of RRSP and the meeting of the directors of national remote-sensing centres and programmes in the ESCAP region was held at Hyderabad during September 1991. India has also been sponsoring long-term fellowships for individuals from developing countries in the ESCAP region for training activities under its sharing-of-experience programme. Assistance was also extended to other developing countries under this programme for training in space applications.

Access to data from IRS satellites is offered to interested countries. Information relating to this has been disseminated to interested countries. India has been participating in the international efforts for satellite-aided search and rescue. The local user terminal and mission control centre in India continued their operations.

India continued its participation in international forums such as IAF and COSPAR. Under the aegis of the IAF Committee on Liaison with International Organizations and Developing Nations, Indian experts have been sharing their experience in the current events sessions for developing nations, organized during the IAF Congresses.

In the pursuit of the goals of the exploration and peaceful uses of outer space, the Indian Space Research Organization continued to promote

international relationships on either a commercial or a cooperative basis, with the national/international organizations engaged in the activities pertaining to this field. Cooperative arrangements are continuing to be explored or pursued with ARABSAT and the space agencies in Australia, Brazil, China, Japan and Sweden.

An agreement was concluded for reception of data from ERS-1 with the European Space Agency and services were procured for the launch and early-phase support of IRS-1B from the Agency's tracking network.

ISRO has also been pursuing cooperation with the French national agency, CNES, and the DLR in Germany. Several joint activities are pursued under ISRO-DLR cooperation, including the conduct of joint experiments and the extension of tracking support by GSOC for IRS satellite and exchange of scientists. The launch services for initial INSAT-II satellites have been contracted to Arianespace. Following fruitful long-term collaboration with ITC Netherlands, which saw the conclusion of a project on the establishment of a department of human settlement analysis at the Indian Institute of Remote Sensing in Dehra Dun, possible future collaboration is being explored. The cooperative arrangement for setting up a remote-sensing centre in Mauritius is being explored. With the cooperation of the Government of Mauritius, a TTC station to support an IRS-1B mission was established. The National Oceanic and Atmospheric Administration (NOAA) of the United States also extended initial phase tracking support to the IRS-1B mission.

Under the overall agreement between ISRO and GLAVKOSMOS, USSR, for the peaceful uses of outer space, several new collaborative projects have been taken up. The activities included launch and initial phase mission tracking services for the IRS-1B satellite and the study of experiments on board the MIR station. The joint effort was pursued further with the USSR State Committee of Hydrometeorology. Transponder lease services were procured from INTERSPUTNIK's Statsionar satellite. India has also continued cooperative participation in international agencies like INMARSAT, ICAO, SFCG, etc.

Development of space industry and spin-offs

The Indian Space Programme continued its collaboration with industries in India in order to service its own needs, to promote the peaceful applications of outer space and to realize the spin-off potentials of the development and application of space technology.

Under its technology transfer scheme, ISRO continued to promote and support the commercialization of technologies developed in the Space Programme for applications in various national sectors. The three major purposes served by this scheme comprise: (i) meeting the requirements of space programmes and projects through the buy-back of products produced by industry as a result of technology transfer; (ii) servicing the rapidly expanding space applications markets in India generated by the Space Programme in the areas of satellite communications, TV and radio broadcasting, meteorological observations, remote

sensing for natural resources survey and management; and (iii) exploiting the full potential of the indigenous technologies developed by the Space Programme for multifarious spin-off applications.

By the end of the early half of 1991, the total number of technologies transferred by ISRO reached 169. These cover a wide spectrum of technological disciplines, with some 32 per cent belonging to telecommunications, meteorological and television related hardware, 47 per cent related to chemicals and materials, 29 per cent electronic/electromechanical and computer systems and the rest in the nature of optical/opto-electronic and mechanical systems.

ISRO has also been providing consultancy to industries to serve their technological upgrading and diversification needs. A large number of industries, including small-scale ones, participate in various tasks and services related to space projects and applications. Nearly one third of the number of technologies transferred by the Space Programme have spin-off markets. ISRO, through its technology transfer office, has been encouraging the wider dissemination of technologies and products developed in the Space Programme having potential for spin-off applications and for the peaceful application of outer space not only within India but in other interested countries.

NORWAY

[Original: English]

Membership in the European Space Agency (ESA) has given Norway effective tools for the strengthening and further development of national industries and for meeting the needs of Norwegian scientists and other users within certain preferred areas. These are areas where Norway may claim the ability to compete internationally, based on indigenous advantages and qualifications as well as special requirements. The Norwegian Space Centre is responsible for Norwegian interests in ESA and will also contribute to the development, coordination and evaluation of Norwegian space activities generally.

ESA contracts with Norwegian industry have shown a considerable increase over the last years. In 1990 such contracts were concluded for 100 million kroner or, cumulatively for 360 million NKr for the period ending that year. The total space-related turnover from 1989 to 1990 increased by 300 million NKr to 1,200 million NKr. These figures prove that Norwegian industries have been successful in qualifying as partners to the main European contractors as well as to subcontractors. Thus, Norwegian industries are about to become a part of the European industrial network in this field, and are thereby expanding their basis for further growth. In 1990 the Norwegian Space Centre took initiatives aiming at a stronger concentration on fewer and bigger enterprises with emphasis on industrial achievement in the distribution of supporting grants. The first steps have also been taken towards a stricter concentration on central ESA programmes.

The gradual readjustment of the national Earth observation programmes towards user orientation has been continued in 1990. User adaptation and user co-financing are time-consuming processes, and the Norwegian Space Centre has tried to adjust the investments accordingly. The Centre's Earth observation programme is to a large extent concentrated around ESA's ERS-1 satellite with radar as its main sensors. The ERS-1-related national users' programme is financed 50 per cent by the Norwegian Space Centre and 50 per cent by other sources. A national ERS-1 project has been prepared for 1991 in order to achieve better coordination of the smaller programmes and to favour the utilization of resources.

The Andøya Rocket Range, part of the Norwegian Space Centre, enjoyed high activity in 1990 with the launching of 92 rockets. At present facilities are being expanded to make possible the launching of bigger rockets. This expansion should attract a broader group of users. Furthermore, the Space Centre has signed with ESA a so-called Special Project Agreement which will guarantee activities on the rocket range for the period 1991-1995.

In Norway, the Norwegian Space Centre bears responsibility for space-related basic research as far as techno-administrative support is concerned, mainly through ESA projects. In 1990 it was decided to begin phase A of the international project AURIO under Norwegian leadership. AURIO will fly on the Polar Platform and is a comprehensive and systematic project for carrying out studies of the northern lights (aurora borealis).

As from 31 December 1990, the Tromsø Satellite Station (TSS), formerly an independent foundation, was taken over by the Norwegian Space Centre. TSS constitutes a central part of the strategic plans for the evolution of Earth observation services and of the industrial development in Norway. TSS has a central role to play for ESA, both for the Norwegian rescue service in connection with the acquisition, processing and distribution of data from emergency beacons and in connection with the national backing of ESA's ERS-1 satellite. To acquire data from ERS-1, scheduled for launch in May 1991, 60 million NKr has been spent on the expansion and development of TSS. The incorporation of TSS into the Norwegian Space Centre has given rise to an extensive restructuring of its economic and commercial organization. This process has resulted in a considerable strengthening of the economy of the satellite station.

The basis for space activities in Norway is to be found in the National Long-term Plan for Space Activities, which is revised in the first quarter of every year. The Plan is drawn up in cooperation with the other parties concerned. The main tasks and strategies are to be found in the document "Strategic Basis of the Norwegian Space Centre", which is also revised annually and published at the same time as the Plan.

In the course of 1991 the ESA Council will meet on a ministerial level. The conference will adopt revised plans for ESA's future work in the shape of a New Long-term Plan. It is important for Norway to take advantage of this process in order to advance our national priorities. The new Plan is expected to lead to an extension in time of some of the existing ESA programmes and a reduction of their size as compared to earlier plans. Space stations and space planes in particular will in all probability be targets for considerable adjustments.

The new plans will in any case mean a strong growth in ESA budgets over the coming years. Norway's adaptation to quick changes of this kind will be problematic. The risk of being left behind in European progress is real. A strong increase in ESA programmes may result in fewer possibilities for Norwegian industries to improve their know-how through national programmes unless the space budgets keep time with the development of ESA programmes.

The Norwegian Space Centre makes a point of concentrating on the most important programmes and in 1991, in cooperation with the Ministry of Industry, will aim at a considerably increased participation in the ESA Ariane-5 programme while downgrading the space plane programme. Norwegian participation in and initiatives concerned with the space station programme will be more closely scrutinized in the first half of 1991. Norwegian industries are at present receiving contracts far in excess of what the ESA Convention indicates.

In connection with the Council conference at the ministerial level, the Norwegian Space Centre, in cooperation with Norwegian Telecom, will examine Norway's role vis-à-vis ESA's telecommunication programmes. The national programmes for Earth observation will stress market development through

increased consideration of users' needs and co-financing. In addition, industrial activities will be promoted. These factors give promising prospects for the international marketing of Norwegian products in the field of Earth observation. The Earth observation programme will also be more heavily concentrated on management of the environment.

The continuation of ESA's science programmes with an annual growth rate of 5 per cent has been decided upon for the period up to and including 1994. SOHO/Cluster, a satellite system for the study of the interaction between the Earth and the Sun, will be the greatest challenge over the years to come.

POLAND

[Original: English]

The Space Research Centre of the Polish Academy of Sciences, in conjunction with a number of scientific institutes and laboratories, was involved in the Intercosmos cooperation programmes and in the implementation of several bilateral agreements with Austria, Denmark, Finland, France, Germany, Ireland, Norway, the Netherlands, Sweden, Tunisia, the United Kingdom and the United States. Poland has initiated negotiations with the European Space Agency (ESA) with regard to joining the above-mentioned programmes and agreement should be signed in 1992.

Some interesting results of Polish activities in this field are described below.

1. Space physics

The main efforts in the field of space physics have been devoted to various activities associated with the participation in current space missions, the design and construction of scientific equipment for future projects, data processing and analysis of measurements from space missions and theoretical studies.

Space missions

Polish equipment installed aboard the Gamma-1 satellite for determination of spacecraft altitude has been operating satisfactorily since launching in 1990.

Construction of equipment

The following equipment is currently being constructed in Poland:

- A few wave analysers for ionospheric and magnetospheric studies;
- Photometers and Dopplemeters for solar observations within the X-ray range;

- A Mossbauer spectrometer for chemical analysis of the surface of Mars;

- A high-energy neutral particle detector.

The above-mentioned equipment is to be utilized in several Intercosmos space projects: Apex, Interball, Coronas-1, Relict-2, Mars-94 and Regatta. In addition to these projects a special wave analyser for a NASA high-altitude rocket is being constructed.

Data processing and analysis

Data processing and analysis of measurements from space has been mainly focused on waves generated in space plasmas: the ionosphere and interplanetary medium. The ionospheric data have been obtained from Polish analysers and impedance meters installed aboard the Activny and Cosmos-1809 spacecrafts. The interpretation of the wave data from the Vega and Phobos interplanetary missions was also continued during the year under review.

Theoretical studies

Theoretical studies are concentrated on:

- The Earth's magnetosphere and ionosphere, as well as the magnetosphere of the largest planets;

- The heliosphere (problems of interaction of the local interstellar medium with the solar wind plasma, penetration of the neutral interstellar gas and galactic cosmic rays into the solar system);

- Plasma phenomena in interplanetary space;

- The dynamics and physics of minor bodies in the solar system;

- Solar X-rays.

International cooperation

All experimental and theoretical activities are conducted in close cooperation between Polish institutes and their counterparts abroad, including: Institute of Space Research in Moscow, IZMIRAN, USSR; Institute of Mechanics in Moscow; Institute of Astrophysics, Bonn University, Germany; Max Planck Institute for Aeronomy, Lindau, Germany; Astronomical Institute in Ondrejov, Czechoslovakia; Swedish Institute of Space Physics, Kiruna, Sweden.

2. Satellite geodesy

To some extent this work represented the continuation of previous research programmes. The activities were focused on Earth tides, the gravity field and geoid, crustal motions and the Mars gravity field study. Some applications of satellite geodesy were considered, among them geodetic networks and navigation. In terms of methodology the activities were concentrated on measurements and satellite observation data processing methods, analysis and theoretical work.

A very substantial element of the activities in general is international cooperation with institutes from the United States, France, Germany, the USSR, Czechoslovakia, Bulgaria, Finland, Sweden, Austria (e.g., in the Baltic Sea Level Project).

3. Remote sensing

New methods have been developed recently for the application of satellite and aerial images to mapping of different objects, processes and phenomena such as land use, forest damage, lake water quality assessment, soil, moisture assessment, anthropogenic impact on environmental changes. These methods are now being implemented and improved.

At present, scientific research is mainly focused on the utilization of microwave satellite data and geographical information systems (GIS). SINUS-GIS has been developed in Warsaw for the purposes of regional environmental monitoring and regional planning. It is located at the Polish Remote Sensing Centre (OPOLIS), Institute of Geodesy and Cartography. The remote data are among the information sources there. A GRID reference point will be established in our country in the near future.

The special equipment for the acquisition of remote-sensing data is being developed at the Space Research Centre of the Polish Academy of Sciences in Warsaw. Scientific research on remote sensing is being conducted at the Polish Remote Sensing Centre, Institute of Geodesy and Cartography, Warsaw, at the geographical faculties of many universities and at the State Hydrometeorological Institute.

4. Biology and medicine

Research was continued on the problems of space biology and the medical examination of the muscular system under conditions of weightlessness. It was established that the satellite cells, which are active in development and regeneration processes, exhibited degeneration.

These changes in the animals on board the biosatellite for over 21 days allowed an explanation to be given in some ranges of the degenerative processes in astronauts during orbital flights.

The heart muscle cells were also examined during 14 days of orbital flight. The results obtained indicated that metabolic disturbances led to cell atrophy.

These results have both practical and cogitive implications for orbital flights of long duration.

The next problem to be examined was the influence of different linear values of radiation transmitted into cells. It was demonstrated that extreme values of radiation already caused the death of cells. In addition, a model of a detector was designed with the capability of making spectral indications of radiation doses in the linear energy transfer (LET) function. The instrument is designed for the measurement of the microdosimetric characteristics of cosmic radiation, especially in biological experiments and in the area of radiation protection.

5. Satellite communications

Research and design work was carried out in connection with the planned introduction of the direct broadcasting satellite system in the 12 GHz band for Poland. Electromagnetic compatibility research and analysis was conducted for new Earth satellite stations in Poland.

Other research projects dealt with digital television systems as well as highly specialized coding methods (with bit rate reduction) for digital high-definition signal transmission from broadcasting satellites.

Research work was continued on radio-wave attentuation of the 11 GHz and 18 GHz as a result of the precipitation on horizontal and elevated paths of the same azimuth. Other investigations were carried out on the meteorological impact on depolarization of microwaves in specific measurements of the orthogonal factor (XPT) of heavy rain at different main polarizations.

UKRAINE

[Original: Russian]

In the activity of Ukrainian organizations and enterprises in the field of the investigation and utilization of outer space, priority has been assigned to the conduct of economic programmes. The development by scientific institutions, over the past decade, of theoretical foundations and procedures for remote sensing of the Earth's surface from space, and the production of one-of-a-kind equipment for this purpose, have made it possible to move on to drawing up the overall "Design of the Ukrainian geo-environmental information system", whose purposes include monitoring of natural resource exploitation and the environment in Ukraine. The system offers the possibility of arranging to supply users with the thematically processed data required to deal with the multiplicity of issues affecting the national economy. Its

priority functions are to monitor and forecast the environmental consequences of the accident at the Chernobyl nuclear power station and the pollution of the waters of the Black Sea and the Sea of Azov, and environmental monitoring of the highly polluted Dnepr region.

In structural terms, the Ukrainian geo-environmental information system will include information compilation, processing and documentation centres, observation facilities (space platforms, small high-altitude aircraft, vehicle-mounted and shipboard ground facilities, etc.) and data transmission channels. The organizations established as a result of the development of this system are capable of producing colour-composite maps, routinely obtained from aircraft in the specified regions, of the radiation picture of the Earth's surface, the depth at which groundwater reserves are located, subsoil moisture levels, thermal fields from natural features and industrial facilities and other parameters.

Ukrainian organizations have participated in developing space facilities for the natural resource use and environmental monitoring system. In particular, work is being conducted on the processing and fabrication of the "Okean" spacecraft, which is a promising unified multi-purpose intermediate-class space platform whose purpose is to provide, over a 10-15-year period, state-of-the-art solutions to a wide range of problems.

Technical proposals have been prepared for all the production of the "Goroskop" satellite communication system based on a specialized communication spacecraft. This system is capable of solving the problems of providing telephone, telegraph, telex and facsimile communication and transmitting digital information, establishing a unified automated air traffic control system and an automatic early warning and operational communications network in regions affected by natural disasters and setting up networks for centralized remote automatic monitoring of the operation of nuclear power stations and especially complex and dangerous facilities.

Ukrainian organizations have participated in the work that has been begun on solving the problem of monitoring the Earth's seismic activity and forecasting earthquakes by establishing a system which should include the existing ground station network of the seismic service, a satellite system comprising an orbital grouping of 6-10 spacecraft, and also a ground-based management complex.

Work has continued on the theoretical analysis and refinement of procedures and software for aerospace methods of studying natural resources and the physical characteristics of the Earth's surface and that of the oceans and seas in the interests of the country's economy.

The Marine Hydrophysics Institute of the Academy of Sciences of Ukraine has conducted, within the framework of the "Kosmos" project, a theoretical analysis of various methods and various radiation models of the atmosphere applicable to the conduct and interpretation of remote measurements in the infrared range.

A databank on the measurements conducted by the "Trasser" optical spectrometer from the "Okean" satellite has been established, and software has been developed for IBM PC/AT personal computers which makes it possible to process and depict global maps of various parameters of the ocean in the form of false-colour images and isolines on the monitor screen. Eight months (from March to October 1990) of continuous monitoring of the Black Sea and the Mediterranean Sea have produced more than 300 daily, 10-day and monthly maps of hydrometeorological fields which make it possible to solve a wide range of practical regional problems.

Under the "Priroda" project, scientific programmes have been developed for experiments using remote-sensing equipment on board the "Mir" orbital station.

A great deal of attention has been paid to developing models of energy and mass transfer in surface regions of the atmosphere-Earth interface.

A great deal of experience has been accumulated in Ukraine on the manufacture and operation of space systems, and extensive fundamental research is under way aimed at developing new materials and technologies associated with the specific conditions of space flight. Various procedural and biological aspects of the prolonged residence of a crew on board an orbital station are being developed. A great deal of work is being conducted on the preparation and conduct of experiments to investigate the Sun and other bodies of the solar system using spacecraft.

A highly effective numerical method of solving equations of motion has been developed. Application of the method to calculating thermo-elastic deformations of lattice structures mounted on board space platforms has made it possible to reduce the consumption of machine time by one order of magnitude in comparison with traditional methods.

A review was conducted of the six years of activity under the "Variatsiya" comprehensive space experiment using "PION" passive calibration satellites. In the course of the experiment, new data were produced on the aerodynamic characteristics of spacecraft and the variations in atmospheric density during the period of maximum solar activity, and a considerable body of data on the deceleration of satellites was accumulated.

Under the "Okean" programme, extensive studies were conducted aimed at producing a new antennae module for measurements of orbital parameters and developing the technology for manufacturing components of antenna-wave devices.

Studies were also conducted of the multi-layer components of the heat-shielding panelling of reusable spacecraft. The work was carried out on a special test bench for investigating the resistance to vibration of materials and structural components in a high-temperature gas flow. It afforded an assessment of the performance of the heat-shielding on actual reusable spacecraft, and enabled recommendations to be developed for selection of the optimum and most reliable structures for use in the heat-shielding systems of such spacecraft.

An experimental model of a self-contained heat engine for a space-based testing facility was produced. Through testing and debugging of the structures, acceptable engine characteristics for practical use were arrived at. A multi-sample electromechanically driven force application device has been developed to refine the procedure for testing materials for low-cycle fatigue through sign-variable bending of flat samples. A working design has been developed for an apparatus with a self-contained solar-energy-powered drive system for low-cycle testing of construction materials.

In the course of cosmic-radiation sounding of the interplanetary plasma at large elongations by the Institute of Radio Astronomy of the Academy of Sciences of Ukraine, an increase in the scattering properties of the medium in certain directions was detected. Significantly, they coincide with the lines of force of the solar magnetic field.

A new mechanism has been proposed for the generation of the sporadic decametre S-radiowave emissions from Jupiter which affords an incontrovertible explanation of a whole series of experimental findings - form and structure of the radiation diagram, frequency drift, angular dependence of radiation frequency, etc.

The DIFOS instrument to study the 160-minute oscillations of the sun is being developed in the main astronomical observatory of the Academy of Sciences of Ukraine, jointly with the Academy's Institute of Physics and Mechanics, under the KORONAS (comprehensive orbital circumterrestrial observations of the active Sun) project. For the implementation of this project, the AUOS-SM spacecraft-platform has been developed; this is to be used as a base for launching, over the period 1992-1995, three spacecraft to carry out the KORONAS-I, KORONAS-F and Foton projects.

With a view to comprehensive study of the effects occurring in the plasma around a satellite and the Earth's magnetosphere and ionosphere, the Interkosmos-24 spacecraft, developed with the active participation of enterprises in Ukraine, was launched in 1989 by a Tsiklon carrier rocket. Following the launch, the Magion-2 sub-satellite developed by Czechoslovakia, the purpose of which is to measure the spatial characteristics of the Earth's magnetosphere, was separated from it. Organizations in Bulgaria, Hungary, Japan, Poland, Romania and the United States of America also participated in the implementation of the project.

Under the national programme, a series of space biology experiments has been completed. The patterns of growth and of the changes in structural and functional organization of Chlorella cells under microgravity conditions have been established. The basically uniform nature of the changes in cell ultrastructure that take place testifies to their adaptive significance. The desirability of using Chlorella as a component of the autotrophic element in controllable life-support systems on board spacecraft has been demonstrated.

Ukraine has made its contribution to the development of international cooperation. Techniques developed by institutes of the Academy of Sciences of Ukraine for solving environmental problems by remote methods have been approved and recommended for inclusion in the international Ekologiya project for 1991-1995. Ukraine's Carpathian and Dnepro testing grounds have been defined as base sites for the sub-satellite measurements under the Ekologiya and Priroda projects. Resurs-series satellites and Mir will be involved in implementing these projects.

Organizations in Ukraine have developed jointly with Germany the design of the LEOSAT-OKEAN space system for monitoring natural resource exploitation and the state of the environment.

In view of the interest of a number of countries in the problem of space-based monitoring of tropical cyclones, a design has been developed for an international system for monitoring precipitation in the tropical zone, monitoring the generation and development of tropical cyclones, and studying the possibility of artificial modification of tropical cyclones in the generation stage. With reference to Ukraine, this system could be used to monitor and predict southern Black Sea cyclones.

The Institute of Geological Sciences of the Academy of Sciences of Ukraine has signed a protocol on commercial cooperation with the Hungarian firm Kevikor on the introduction of a technology developed by Ukrainian scientists for remote environmental monitoring.

Pursuant to the 1987 Agreement between the Union of Soviet Socialist Republics and the United States of America concerning Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes, a congress-seminar of the Soviet-American "Earth Science" group on problems of remote sensing of the ocean was held in July 1990 at the Marine Hydrophysics Institute of the Academy of Sciences of Ukraine.

Staff of the N. G. Kholodny Botanical Institute of the Academy of Sciences of Ukraine have conducted jointly with the European Space Agency the Protodin experiment, using plant cell protoplast to study the biological effects of microgravity at the cellular and sub-cellular levels.

Institutes in Ukraine have made preparations for participation in the International Space Year.

The appointment of Ukraine at the forty-fifth session of the General Assembly as a member of the Committee on the Peaceful Uses of Outer Space has opened up new possibilities for the expansion of Ukrainian participation in international cooperation in the outer space field.

UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND

[Original: English]

1. United Kingdom space policy

The United Kingdom civil space activity is managed and funded via the British National Space Centre (BNSC). BNSC is the instrument for implementing space policy for a range of government departments including the Department of Trade and Industry, the Foreign and Commonwealth Office, the Department of Education and Science, the Ministry of Defence and the Department of the Environment.

The policy that is being followed is formulated interdepartmentally at the ministerial level. The guiding principles of United Kingdom policy are that all major programmes should involve international collaboration and concentrate on areas that will produce benefits for the United Kingdom and mankind in general. To this end Earth observation is the area of primary concern. Satellite communications technology is also covered as a priority area, as well as space science, technology and transportation.

In support of the goal of international collaboration, two thirds (£94 million) of the total United Kingdom civil space budget (about £148 million) is directed via the European Space Agency (ESA), with the balance of approximately £54 million spent on the national elements of the programme. It is also current policy which leads us at this time not to support the development of the capability for manned space flight. We have however proposed two United Kingdom candidates for the ESA astronaut corps and recognize the part played by private enterprise and the USSR which led to Helen Sharman being the first European woman in space following her eight-day mission, which included a visit to the Mir space station in May 1991.

Formed in 1985 as a partnership between United Kingdom government departments and research councils, BNSC provides the focus for Britain's non-military space interests. The following organizations are participating: Department of Education and Science (DES), including the Science and Engineering Council (SERC) and its Rutherford Appleton Laboratory (RAL), and also the Natural Environment Research Council (NERC), with its Remote Sensing Applications Development Unit (RSADU); Department of the Environment (DOE); Department of Trade and Industry (DTI); Earth Observation Data Centre (EODC) with National Remote Sensing Centre Ltd. (NRSCL); Meteorological Office; Foreign and Commonwealth Office (FCO); and, finally, the Defence Research Agency of the Ministry of Defence (MOD), with the Royal Aerospace Establishment (RAE) and the Royal Signals and Radar Establishment (RSRE).

United Kingdom space programmes are funded through BNSC by these partners. BNSC advises the Government on space developments and opportunities and enacts the resulting policies, working closely with specialists at various technical centres throughout the United Kingdom and bringing together government, the public sector, academia and industry.

2. Earth observation

Earth observation continues as the main thrust of United Kingdom civil space activities, providing information with a real direct and beneficial effect on human lives. Focal points of BNSC's Earth observation programme during 1990/91 have been the preparations for ERS-1 (ESA's first European Remote Sensing Satellite), and UARS (NASA's Upper Atmosphere Research Satellite). Both carried instruments provided by British scientists, and were launched in 1991. On a national level, the preparation and development of the Earth Observation Data Centre was the key activity.

ERS-1 is ESA's first low polar orbit Earth observation satellite. Its suite of instruments will generate vast amounts of data - perhaps most importantly, measurements of sea surface temperature and of ocean/wind/wave patterns which will revolutionize the understanding of global Earth/atmosphere energy transfer systems.

During normal operations, ERS-1 will provide global data sets on a 35-day repeat cycle. Marconi is leading the development of its principal instrument, the Active Microwave Instrument (AMI), which will operate as a synthetic aperture radar (SAR) to take images of the Earth's surface, or as a scatterometer to make wind/wave measurements. AMI's radar will be able to take images through cloud and rain and at night, and will have commercial applications, particularly in environmental monitoring.

Also present on the flight is the Along Track Scanning Radiometer (ATSR), which monitors sea surface temperatures with unprecedented accuracy and is provided nationally through the Science and Engineering Council.

Upper atmosphere research

Ten instruments, two from the United Kingdom, will fly on UARS. UARS will make major contributions on a global scale to the understanding of the atmosphere by helping to measure the chemistry and dynamics of the stratosphere and mesosphere. The British instruments are the Improved Atmospheric and Mesospheric Sounder (Oxford University and Rutherford Appleton Laboratory, with industry) and the Microwave Limb Sounder (consortium led by Heriot-Watt University). Both will provide information on the chemistry of the upper atmosphere.

Meteorology

Today, weather forecasting and satellites are closely linked. The United Kingdom Meteorological Office routinely uses satellite data, with hourly images of northern Europe and Africa being provided by the geostationary Meteosat series of satellites, operated for the Met Office by Eurimage. In 1990 Meteosat 5 was launched in readiness to succeed Meteosat 4. Improved vertical soundings of water vapour and temperature will be provided by a new instrument being built by British Aerospace for the Met Office to fly on the first Polar Platform.

Earth Observation Data Centre

The £20 million Earth Observation Data Centre (EODC) will act for the United Kingdom in handling and making available data from ERS-1 and subsequent Earth observation missions. Its development has been funded by Government, and work on it (by a British Aerospace-led consortium) began in 1988. From its inauguration, EODC will be managed and operated by industry; by 1997 it will become a self-sustaining business. EODC will be one of the four ESA processing and archiving facilities established within Europe to handle data, initially from ERS-1. It will be the primary source of information for the SAR and for all other ERS-1 instruments over land and ice.

The increasing number and complexity of satellites through 1992 will bring a quantum increase in data and will require ever more sophisticated handling, storage, processing and dissemination; EODC will claim its share. BNSC is setting up and joining an intense debate to ensure that users can take the greatest advantage of the data. The debate covers the requirements for global climate research and is particularly scrutinizing the rules, costs and other means of international data exchange.

National Earth observation programme

The national programme in Earth observation made good progress on defining and designing a high-resolution optical mapping instrument and an advanced SAR. Both instruments are seen by United Kingdom industry as vital to the full development of any commercial market for satellite data. BNSC plans to confirm the feasibility of the designs, in order to persuade ESA to incorporate them in future missions.

A second major strand of the programme has been to develop techniques to help in understanding the information content of data prior to including them in demonstration projects; this work, undertaken by industry, academia, RAE, RAL and NERC's Remote Sensing Applications Development Unit (RSADU), has both commercial and environmental applications.

Applications

A priority of BNSC is to show how data can be used operationally. During 1990 a new programme (using satellite data to build up a land-cover map of the United Kingdom), was begun by RSADU; the United Kingdom Land Cover Mapping Project involves the automatic classification of Landsat and SPOT satellite data into land cover categories.

Over the oceans, another study carried out for BNSC by NERC on global significant wave height data (from the United States Navy satellite GEOSAT, 1985-1990) indicated a 1-metre increase in January wave heights near the United Kingdom and an equivalent decrease in the north-east Pacific. Such findings have major importance for offshore structure design and may provide indicators of climate change.

Future plans

Major forthcoming developments are ERS-2 and the ESA Polar Platform polar-orbiting Earth observation mission. ERS-2 will provide vital continuity for ERS-1 data; in contrast, the Polar Platform will carry a much larger suite of instruments on a completely new platform, for which the design is well advanced. The instruments should advance to the main design phase late in 1991, and are aimed at the meteorological, environmental, scientific and commercial markets. The Polar Platform mission is part of a wider international programme, with missions to be flown by the United States and Japan.

BNSC provides the United Kingdom with a clear voice in programme discussions, and within the United Kingdom has set up an Earth Observation Programme Board, with members from industry, academia and other government departments. The Board enables BNSC to draw upon a wide range of expertise and skills.

3. Space science

Space-based research is essential, for studies from space record observations at wavelengths which the atmosphere absorbs and enables us to detect plasma (ionized gas), measure magnetic and electric fields in space and send missions to other planets. The United Kingdom has a long tradition and a high reputation for its space science, and today works primarily within ESA science programmes, with advice from the BNSC Space Science Programme Board, which provides guidance on the selection of missions and on management of the national programme. This work is funded by SERC, which in universities and in RAL supports the development of new instruments for space missions and the interpretation of their data. Highlights of the year include the thousand-plus new extreme-UV sources found by ROSAT, affording a better understanding of the aurora, as well as important new black hole measurements by the International Ultraviolet Explorer (IUE).

European Space Agency science programmes

These programmes fit within an overall framework - "Horizon 2000" - which the United Kingdom helped conceive and plan; the United Kingdom has contributed to all ESA science missions and worked closely and successfully with ESA to give Horizon 2000 a thorough management and cost review, which is currently being implemented.

ESA took part in two joint missions with NASA during the year; the Hubble Space Telescope (launched April 1990), a 2-metre astronomical telescope, for which British firms built the solar arrays and British academic groups helped design the Faint Object Camera (which is working well despite the problems with Hubble's main mirror); and Ulysses (launched October 1990), the first mission to the solar poles, for which British groups provided equipment to study low-energy ions and electrons, magnetic fields and cosmic dust particles.

Existing missions

United Kingdom space science continued to benefit from a number of current missions:

- International Ultraviolet Explorer (IUE), still returning excellent data despite its long time of operation (especially measurements of the distance of the UV gas clouds from the massive central black hole);

- Hipparcos, ESA's ongoing star-mapping mission;

- Giotto, which successfully intercepted Halley's comet during the 1980s; various United Kingdom instruments are still functioning and will be used to study a second, older comet (Grigg-Skjellerup) in the Giotto Extended Mission (GEM)

Future missions

Preparatory work continued on various future missions:

- Infrared Space Observatory (due for launch in 1993): United Kingdom academic groups are developing ISO's Long Wave Spectrometer and contributing to its camera and photometer. ISO will study the formation of stars, galaxies and other objects;

- SOHO/Cluster (due for launch in 1995): United Kingdom groups have leading roles in four instruments and are playing major roles in five others. SOHO/Cluster are twin missions to study Sun/Earth interaction, SOHO as a solar heliospheric observatory sited at the gravitational balance point between the Sun and Earth, and Cluster as a group of four identical spacecraft giving three-dimensional information about magnetic and electrical fields;

- Cassini/Huygens (due for launch in 1996): a joint ESA/NASA mission to Saturn and its moon Titan. United Kingdom groups will develop instruments both for NASA's Cassini mission (to orbit Saturn) and for ESA's Huygens probe (to land on Titan, an Earth-sized body possibly possessing a hydrocarbon sea).

Bilateral ventures

The United Kingdom collaborates selectively on a bilateral basis with other countries if funds allow, so that British scientists can take part in a well-balanced programme.

The German/United States/United Kingdom X-ray satellite ROSAT was successfully launched in June 1990 and has carried out an all-sky survey. The United Kingdom provided the wide field camera.

The United Kingdom is also leading a European consortium to build an X-ray telescope (JET-X) for the USSR Spectrum-X mission (scheduled for launch in 1994) and is providing X-ray instruments for the Japanese Solar-A (launch, August 1991) mission, to study the high-energy aspects of solar flares.

Microgravity

Space science also covers the study of materials and organisms under the very low gravity conditions offered by orbiting spacecraft. Research in this field is still in its infancy, but BNSC invests modestly in ESA's optional microgravity programme, to provide flight opportunities for the small but active United Kingdom microgravity community.

4. Satellite communications

Olympus

BNSC has made a priority of encouraging users to develop and demonstrate new service concepts via ESA's Olympus communications satellite (launched 1989), and ground stations. Such concepts have included the broadcasting of educational materials throughout Europe by the Eurostep organization and data transmission experiments in D2-MAC by British Telecom. One Olympus experimenter has now started commercial broadcasting of education services on the Astra satellite, meeting or exceeding preset commercial objectives.

Other ESA programmes

The United Kingdom decided to take part in the following new ESA communications satellite programmes:

- DRTM, a programme with two elements: a data relay satellite system and a technology mission (Artemis). Both commenced during 1990. Artemis will demonstrate new, advanced technologies such as communicating to land-mobile terminals, on-board processing and optical inter-satellite data links for high-bandwidth data. DRS will support a number of ESA programmes, and for the Polar Platform will transmit high-bandwidth data to Earth over areas which have no ground stations;

- ASTP-4, the Advanced Systems Technology Programme, slice 4, is ESA's generic satellite communications support programme. The United Kingdom has obtained good value from previous phases of ASTP and expects to use it to lay the foundations for encouraging industry to devise novel uses for communications satellites.

Private sector funding

ESA communications satellite programmes frequently lead to successful commercial development. Within ESA BNSC is encouraging the option of private-sector funding for the new communications satellite programmes (particularly during the definition phases) and plans, in collaboration with potential users, to use such programmes to stimulate specialist markets.

Non-ESA programmes

In January 1991, Matra Marconi Space (with the United States company GE Astrospace) won the contract to provide INMARSAT-3, the payload technology for which is derived from ESA's technology programme. This is an important example of United Kingdom industry commercially exploiting ESA research and development programmes.

5. Space technology

An independent Space Technology Advisory Board, drawn from industry and academia, helps BNSC ensure that the best use is made of available resources, including investment from the private sector. The primary aim of the programme is to improve the cost-effectiveness of space missions. The principal means of achieving this are by lengthening satellite life, reducing weight for a given performance and lowering costs. Programmes given BNSC support in the past have now successfully matured.

The Royal Ordnance Leros-1 dual-mode Apogee engine is used on the Astra 1B satellite, and 14 units have now been sold to the United States. A further development, Leros-2, is being funded by Royal Ordnance.

The United Kingdom is at the forefront of spacecraft solar cell research and development, particularly Pilkington cover glasses. These have been sold to most satellite manufacturing nations, including China.

BNSC supports the UK-10 ion propulsion system, a long-life fuel efficient system which flies on ESA's Artemis technology satellite and promises to increase the life of communications satellites.

The Stirling Cycle Cooler, developed jointly by RAL and others, will provide longer-lived and more efficient coolers; this is particularly important in Earth observation and within instruments. Several have been sold by British Aerospace.

BNSC continues to encourage the development of new technologies for space applications, for example, the Atomic Energy Authority's lithium polymer battery technology, which has promise for space applications.

6. Space transportation

The downrange tracking station on Ascension Island, which supports Ariane launches from Kourou, was formally opened for service in 1991. The station is operated by Cable & Wireless in agreement with CNES, the French national space agency. Britain has been actively involved in ESA/United States discussions on possible "rules of the road" for government support to commercial launch services. Parallel discussions covered Europe's policies towards Chinese and Soviet commercial launchers.

7. International cooperation and education

ESA and the European Community

The European Community is developing space policies, on which BNSC is coordinating a United Kingdom view; this encourages the Community into roles complementary to those of ESA and avoids duplication of ESA's work in developing space technologies. BNSC has worked to promote this view both within ESA and in informal contacts with the Commission and representatives of the European Parliament.

Committee on the Peaceful Uses of Outer Space

The United Nations Committee on the Peaceful Uses of Outer Space provides an international forum for space issues. The United Kingdom is represented by BNSC together with the Foreign and Commonwealth Office, and made progress towards its objective of formulating guidelines on the use of nuclear power sources in satellites. Future discussions will address the question of space debris.

Outer Space Act

The 1986 United Kingdom Act provides domestic legislative powers with which the United Kingdom meets international obligations under United Nations conventions on the uses of outer space. BNSC operates the licensing regime under the Act (on behalf of the Secretary of State for Trade and Industry) to ensure in particular that United Kingdom space operators have adequate insurance. Lincences were issued during the year under review to B Sky B (BSB) and Surrey University.

International Space Year 1992

BNSC has been instrumental in the setting up of a new body (BISY - British Industry in Space Year) to act as the focus for and to encourage industrial commitment to United Kingdom space awareness activities within International Space Year. BNSC also continues to take part in parallel European and international scientific preparations for International Space Year.

Education

Today's schoolchildren are tomorrow's industrialists, teachers, engineers and space specialists. Recognizing this, BNSC continues to work closely with the Department of Education and Science to develop remote-sensing materials for use within the secondary science curriculum.

BNSC commissioned a consultancy audit of current initiatives designed to enhance space applications within education.

UNITED STATES OF AMERICA

[Original: English]

The present contribution briefly describes major space accomplishments of participating United States government organizations for calendar year (CY) 1989 and fiscal year (FY) 1990. More detailed information can be found in the documnent "Aeronautics and Space Report of the President; 1989-1990 Activities" published by the National Aeronautics and Space Administration (NASA), Washington, D.C., in 1991.

1. National Aeronautics and Space Administration

Human space flight

Major efforts in NASA's human space flight programme focused on developing space transportation capabilities, carrying out space flight operations, and sending people to work in space. NASA successfully completed eight shuttle missions in CY 1989 and FY 1990. These missions involved deploying a tracking and data relay satellite, the Magellan Venus probe, the Galileo Jupiter probe, Syncom IV (a Navy communications satellite), the Hubble Space Telescope, the retrieval of the Long Duration Exposure Facility and three classified Department of Defense missions.

Another significant activity of 1989 was the naming of the new shuttle orbiter. The name "Endeavour", submitted by schoolchildren in the orbiter-naming contest, was selected for Orbiter Vehicle 105. Endeavour is scheduled to be completed and delivered to NASA in 1991.

A major reassessment of the space station budget occurred in 1989, prompted by a shortfall in the Congressional appropriation for FY 1990. During this review, some management and budget changes were implemented, and some capabilities were deferred until later in the programme. However, the goal for the launch of the first element of the station continued to be March 1995.

In FY 1990 the Space Station programme made considerable headway on preliminary design of hardware elements such as the habitation module, the United States laboratory, the truss structure, the mobile transporter, power and propulsion systems and the attached payloads accommodation equipment. NASA extensively tested hardware for the environmental control system and selected technologies for use in the air and water recovery loops. The programme also refined the requirements for building and implementing all the ground infrastructure essential to operate, use and support the station over its projected 30-year life. Other major programme accomplishments included reducing weight, power and extravehicular activity requirements associated with the current design.

In addition, NASA continued to work closely with its international space station partners in Europe, Canada and Japan. Several coordinated studies and reviews were completed and NASA and the partners continued to work together on the programme-level integrated system preliminary design review expected to conclude near the end of 1990. All four partners agreed on an international standard paylaod rack that would facilitate commonality and payload interchangeability.

Finally, NASA conducted advanced systems studies and planning efforts to identify preliminary reference configurations for potential evolution of the station. This included analysis of possible requirements to support the Space Exploration Initiative (SEI).

SEI was approved by President Bush on 16 February 1990 as a far-reaching programme to return to the moon and press on towards exploration of Mars. On 11 May 1990, the President established a goal for human beings on Mars by 2019. In response to this challenge, on 31 May 1990, NASA established the SEI Outreach Program.

Unmanned expendable launch vehicles

There were 28 unmanned expendable launch vehicle (ELV) launches during the nearly two-year period of the present report. Four spacecraft, originally assigned for launch from the shuttle, were reassigned to ELVs as a part of the mixed fleet strategy developed to assure access to space. All four of these spacecraft - the Roentgen satellite, the Combined Release and Radiation Effects satellite, the Extreme Ultraviolet Explorer and the Mars Observer - were launched or were under contract to launch on ELVs. Also, NASA, in its role as "service provider", allowed access to NASA facilities at direct cost to the commercial launch industry.

NASA also sought to expand cooperative efforts with United States industry to develop space and accelerate the commercial application of space technologies. During 1989 and FY 1990, NASA made special progress in defining an overall programme of commercial space development. To this end, its Office of Commercial Programs' Centers for the Commercial Development of Space engaged significant numbers of United States firms in commercial space development. New technologies, products, supporting transportation and

infrastructure systems, and business enterprises have emerged as a result of these cooperative efforts. The challenge to produce a programme that develops commercial space markets, low-cost commercial space transportation systems and commercial space infrastructure that strengthens United States industrial competitiveness is being addressed through these efforts.

Space science and applications

NASA has continued its ongoing efforts to support future space science missions in the solar system. Calendar year 1989 heralded the beginning of a burst of new activity. In May, the shuttle deployed the Magellan Venus probe; it landed on the planet in August 1990 and began a multi-year mission mapping its surface. In August 1989, after travelling 4.4 billion miles for 12 years, Voyager 2 flew past the planet Neptune, exciting the world with its many discoveries, such as active volcanoes on the moon Triton. In September 1989, the importance of a small mission was demonstrated when an instrument aboard a sounding rocket captured the most detailed series of solar flare images ever obtained. In October 1989, the Galileo space probe began its circuitous journey to Jupiter after launch from the shuttle. Finally, in November 1989, the Cosmic Background Explorer was launched carrying instruments to measure the radiation from the big bang, the primordial explosion thought to have marked the creation of the universe.

NASA also cooperated in search-and-rescue and disaster medical aid in 1989. COSPAS-SARSAT, a satellite-based search-and-rescue system, has saved more than 1,400 lives in total, and the Telemedicine Spacebridge provided medical advice to earthquake victims of Soviet Armenia and later to victims of other Soviet disasters.

The ambitious achievements of 1989 were continued through FY 1990 with a full range of scientific disciplines that included the launches of various satellites including the Pegsat, the Hubble Space Telescope, the Roentgen satellite and the Combined Release and Radiation Effects satellite. A new start was approved for CRAF-Cassini, a programme that will provide unprecedented information on the origin of our solar system. CRAF (the Comet Rendezvous/Asteroid Flyby) will analyse for the first time the solid material of which a comet is made. Cassini, after a four-year study of Saturn, will measure the atmosphere of its largest moon, Titan.

Space communications operations

In 1989, the Tracking and Data Relay Satellite System (TDRSS) became fully operational in geosynchronous orbit, providing communications support to spacecraft in low-Earth orbit. This network provides communication and tracking for over 85 per cent of each spacecraft orbit around Earth, a major advancement in space communications. With the previous ground-tracking network, coverage was limited to only about 15 per cent of a spacecraft orbit. This event brought to reality the long-awaited transition from a ground-based tracking network to a space-based tracking capability for low-Earth-orbit missions. The operational space network allowed NASA to close

or transfer to other agencies the four ground stations. In January 1990, the Second TDRSS ground terminal was dedicated in New Mexico. The new facility provides backup to the first ground terminal and adds the capability to operate future TDRSS satellites when demand increases.

The ground networks of NASA included the Spaceflight Tracking and Data Network, the Deep Space Network, and the Aeronautics, Balloon and Sounding Rocket programmes. All were effectively utilized in 1989 and 1990. They provided tracking and data acquisition support services to all NASA missions for vehicles in high-Earth orbit, in deep space and for suborbital flights. In August 1989, for example, the Deep Space Network performed a nearly flawless operation during the Voyager 2 encounter with Neptune, which was the culmination of a 12-year mission. The Deep Space Network was augmented by non-NASA facilities in Australia, Japan and New Mexico for this encounter. In 1990, the Ground Networks also provided launch and landing support for shuttle missions and tracking and data acquisition support for Magellan, Galileo and Ulysses. Foreign missions were also supported to collect data from the Earth and the moon.

Space research and technology

The primary goal of the space research and technology programme is to develop technologies that enhance or enable our space missions and thereby support United States leadership in space through a broad-based research programme. This programme has continued in a quiet but efficient manner for many years. It serves to advance technology at the concept, subsystem and system levels; to develop technical strengths in the engineering disciplines within NASA, industry and academia; and to perform critical flight experiments where testing in space is necessary.

The space research and technology programme is structured into five technology thrusts, related to space science, space transportation, space station, exploration and breakthrough technologies. In addition, a key element of the programme is developing and sustaining a strong partnership with the university community through the University Space Research programme. This is an integral part of the strategy to strengthen the space research and technology capabilities of the nation. In 1989 and 1990, significant progress was accomplished in many key disciplines such as propulsion, power, information and controls, materials and structures, aerothermodynamics and space flight experiments. This progress will contribute to achieving our future objectives in space science, space transportation, space station, and exploration.

Aeronautics research and technology

NASA's aeronautics programme implementation, in close coordination with industry, the Federal Aviation Administration (FAA), the Department of Defense and other government agencies, continued to be accomplished during 1989 and 1990 through the pursuit of six key thrusts. The first thrust, subsonic transport, is focused on developing technology that will increase the productivity, affordability and competitiveness of United States commercial

transport aircraft. The second thrust, high-speed transportation, is based on resolving critical environmental issues and establishing the technology for economical high-speed air transportation. The research programme's goals focus on resolving problems with atmospheric effects, airport community noise and sonic booms. The third of these, the high-performance aircraft research programme, is structured to develop technologies having important military applications. The fourth, the hypersonics and transatmospheric research programme, is an integrated multidisciplinary effort aimed at building fundamental technical understanding of the controlling physical phenomena of air-breathing hypersonic vehicles. Research has been focused on the development of technologies required for hypersonic cruise in the atmosphere, single-state-to-orbit using air-breathing primary propulsion, and horizontal takeoff and landing. The fifth, the fundamental technology base thrust, has been pursuing revolutionary advances in the basic sciences necessary for the design and operation of next-generation aeronautical systems. And finally, NASA has embarked on a sixth key thrust, a five-year revitalization programme for the unique, high-value experimental wind tunnels, some now more than 30 years old.

2. Department of Commerce

The Department of Commerce (DOC) has four components involved in space activities. As the Earth systems agency, the National Oceanic and Atmospheric Administration (NOAA), through its National Environmental Satellite, Data and Information Service, is the largest space arm of DOC. NOAA is responsible for both the operational polar orbiting and the geostationary satellites and will have several instruments on NASA's Earth Observing System. As operational satellite-derived products are refined and developed, they are used by the country's weather and climate services - government, academic, and private. Satellite data were used in operational forecasting and in studies of severe weather and tropical storms. Expansion continued in the distribution of satellite information from the Advanced Very High Resolution Radiometer, from the Visible and Infrared Spin-Scan Radiometer Atmospheric Sounder and by using GOES-Tap (a program enabling users to acquire high-quality Geostationary Operational Environmental Satellite imagery over telephone data circuits). Studies continued on ozone, cloud occurrence, and snow cover, factors critical to our study of climate change. A new operational programme was CoastWatch, NOAA's coastal land and water programme which obtains environmental information on coastal physical oceanography and meteorology and provides environmental alerts to coastal communities. NOAA initiated projects to acquire, archive and disseminate data packages needed in monitoring the global climate and its change. In international activities, two operational programmes continued: COSPAS/SARSAT and a revitalized PEACESAT (Pan-Pacific Educational and Cultural Experiments by Satellite).

The newest space activities component of DOC is the Office of Space Commerce, which was formally established in 1988. It is the Department's principal unit for the coordination of commercial space-related issues, programmes, and initiatives.

The Commerce Department's National Telecommunications and Information Administration (NTIA) continued its presence on international committees and working groups, as well as working with foreign satellite consortia. NTIA continued in the World Administrative Radio Conference in 1989, participating in an assessment of the 1988 United States position paper of importance to United States space interests. Planning continued for the experiments to be conducted for the Advanced Communications Technology Satellite, under development by NASA. The deployment of mobile millimetre wave measurement systems continued for use in Earth-spacecraft communications.

Finally, the Department's National Institute of Standards and Technology, formerly the National Bureau of Standards, participated in space programme support, including the spectrograph calibration on the Hubble Space Telescope, resolution of unexpected satellite technical development problems and numerous other calibration and standardization studies. Certain high-performance aerospace materials, that is, metallic substances, heat exchangers and advanced ceramics, were under study. In space science research, several spectroscopic studies and analyses of stellar features continue. Research in gravitational and tectonic areas also is going on. In atmospheric research, the following are under study: ozone depletion, the greenhouse effect of other gases and methods of investigating other chemical atmospheric constituents.

3. Department of Energy

The United States Department of Energy (DOE) provides nuclear power sources for NASA space missions. Such power units have enabled spectacular missions like the Voyager flyby of Neptune and the Apollo lunar-surface scientific work.

The radioisotope thermoelectric generator (RTG) programme develops and builds devices that directly convert heat from the fuel plutonium-238 into electricity. Progress included the successful launch of the RTG-powered Galileo and Ulysses spacecraft; continued life testing of over 49,000 hours of a qualification RTG unit; and various actions intended to upgrade and maintain RTG production facilities. In the Turbine Energy Conversion System programme, designed to achieve 18 to 25 per cent energy conversion efficiencies from plutonium-238 fuel, progress included the following: selection of the optimized design parameter; completion of a preliminary turbine alternator compressor design; testing of various subcomponents; and examination of potential missions.

The purpose of the SP-100 space reactor programme is to develop, demonstrate and make available to users space reactor power in the tens to hundreds of kilowatts electric power range. Progress included completion of major system design activities; manufacturing of 75 per cent of the ground-test reactor fuel; a nearly tenfold increase in power density over current thermoelectric technology; a demonstration that the reactor vessel and internal structures could be fabricated; and fabrication of a more prototypic thermoelectric cell.

The thermionic fuel element verification programme, is intended to resolve issues enabling thermionics to be a viable technology for future space reactor systems. Activities consisted of lifetime component testing in accelerated and real-time environments.

4. Department of the Interior

The Department of the Interior uses data acquired by satellite and aircraft sensors to inventory natural resources and monitor changes on lands under its management and maintains an active programme of research and technique development in remote sensing. In 1989 and 1990, the Department continued to archive, process and distribute Landsat and Advanced Very High Resolution Radiometer satellite data. The national aerial photography and side-looking airborne radar programmes acquired data over priority United States areas. Major land-management applications of remote sensing included land-use and land-cover mapping (especially in Alaska), vegetation mapping, wildfire mapping and monitoring, irrigated lands inventory and wetlands mapping and inventory. Hydrologic applications included snow-cover mapping and monitoring and modelling of reservoir surface-water parameters. Oceanographic applications included monitoring of marine-mammal migration. Geological applications included digital image processing for geologic mapping and mineral resource assessment in semi-arid terrains, surface coal-mine monitoring, landslide hazard assessment and volcano monitoring. Planetary studies included data archiving, the Voyager flyby of Neptune's moon, Triton and observation of Earth-approaching asteroids. Cartographic applications included satellite image mapping, digital image-processing research and studies using global positioning systems. Global change research included studies of sea ice, snow, ice sheets and glaciers, and studies of detailed coastal morphology related to sea-level change. Work began on developing information systems to improve access to land-related, remotely sensed and Earth-science data for global-change research, and development of techniques to produce and distribute regional, continental and global land data sets. International programmes were carried out in Africa, the Middle East, Latin America, Iceland and Antarctica.

5. Department of Agriculture

In 1989, space-related activities of the United States Department of Agriculture included basic research on development of plant-growing systems that could be adapted to manned space vehicles and remote-sensing applications research. Although focused on finding optimum growing conditions given certain environmental stress factors, the basic research on development of plant-growing systems can be directly related to plant growth and productivity in the closed environment of a spacecraft. Remote-sensing applications research included demonstrations of the use of digital Landsat data for monitoring sediment in lakes and reservoirs and for monitoring the destruction of defoliated cotton stalks for boll-worm control. An airborne laser profiler was used to determine soil loss caused by erosion.

6. Federal Communications Commission

Communications satellites

The Federal Communications Commission granted authority to the Communications Satellite Corporation (Comsat) to participate in the launch of the final Intelsat V series satellite and the first three Intelsat VI series satellites. The International Telecommunications Satellites Organization's second Intelsat VI launch failed to achieve geostationary orbit. The United States and the United Kingdom completed article XIV (d) consultation with Intelsat for two more United States international satellites to be used by the Orion Satellite Corporation for service between the United States and the United Kingdom.

In 1989, the Commission decided that the public interest requires that the International Maritime Satellite Organization (INMARSAT) aeronautical mobile-satellite services be made available to users in the United States and that these services are best suited for aircraft that are in international flight. The Commission also permitted Comsat to be the United States provider of INMARSAT aeronautical space segment capacity. INMARSAT issued a request for proposals for a third-generation satellite system. The specifications for this system include spot beams and the capability to operate within the full maritime and aeronautical mobile-satellite spectrum. In mid-1990, the INMARSAT Council authorized the Director General to negotiate and award a contract by the end of 1990 for the purchase of three or four Inmarsat III satellites.

In 1989, the Commission authorized the American Mobile Satellite Corporation to construct, launch and operate three satellites in the mobile satellite service, which is expected to be implemented in 1993 and 1994, to provide a variety of domestic land, aeronautical and maritime mobile-satellite services.

Geostar Positioning Corporation commenced two-way start-up radiodetermination satellite service in the United States in 1989. The Commission also authorized Qualcomm Corporation to construct and operate a two-way mobile data communications network to provide a variety of data services between a customer's operation centre and its mobile users.

7. Department of Transportation

Commercial space transportation

The period under review marked a turning point for the Department of Transportation's Office of Commercial Space Transportation and the United States commercial launch industry. The first suborbital and orbital United States commercial launches licensed under the Commercial Space Launch Act took place. On 29 March 1989, Space Services Inc. of America conducted a suborbital launch from the White Sands Missile Range in New Mexico. On 27 August 1989, a McDonnell Douglas Delta rocket lifted off from Cape

Canaveral carrying a British communications satellite. A total of 10 successful launches took place during fiscal years 1989-1990.

Other important highlights for the year include the issuance of 14 launch licences, completion of a study of the scheduling practices and launch operations at existing United States ranges and completion of a preliminary safety review of two proposed commercial launch sites in Hawaii. In addition, the Office of Commercial Space Transportation continues to monitor developments in the world commercial market and advocates Unites States policies to strengthen the competitive position of United States launch firms in the world market. The Office of Commercial Space Transportation also issued six commercial launch manifests. The latest launch manifest, issued in July 1990, lists a total of 35 commercial launch contracts.

8. Environmental Protection Agency

The United States Environmental Protection Agency (EPA) through its Environmental Monitoring Systems Laboratory in Las Vegas, Nevada, routinely conducts research and technical support using remote sensing as part of an overall environmental monitoring programme. Large-scale aerial photography is collected and interpreted to support the provisions of the Resource Conservation and Recovery Act and the Comprehensive Environmental Response, Compensation and Liability Act; medium-scale photography is collected and interpreted to support non-point-source pollution studies, wetlands protection, coastal zone studies and forest-ecosystem decline caused by acid deposition; and high-altitude photography is interpreted for broad area studies in the coastal zone and to contribute land-use and land-cover information in risk-assessment studies. Airborne and satellite multispectral scanner data are collected and interpreted to support water-quality, non-point-source pollution, hazardous-waste and critical-habitat investigations. Airborne laser systems are developed which contribute to air and water monitoring, and a geographic information system is used to integrate multiple data sets in support of all EPA programmes.

9. National Science Foundation

The National Science Foundation (NSF) is the principal supporter of academic research in atmospheric sciences and ground-based astronomy. Major events in the astronomical sciences during 1989 included the use of the Very Large Array radio telescope, in conjunction with NASA's Deep Space Network, to acquire data relayed by the Voyager 2 spacecraft during its encounter with Neptune. During 1989, astronomers mapped the galaxy distribution in the nearby universe, revealing an inhomogeneous distribution of matter, challenging current theories of cosmology. Astronomers also reported the discovery of a population of faint blue galaxies, perhaps the first in the universe to be formed. A combination of measurements by cosmologists at the South Pole and a NASA satellite allowed the cosmic microwave background radiation spectrum to be measured over a wider wavelength range than possible from elsewhere on Earth or in space.

In atmospheric sciences, the MAX'91 programme, designed to study solar disturbances during the current period of high solar activity, was launched. During 1989, scientists reported that studying solar-like stars can assist in predicting our own sun's activity cycles, thus increasing our ability to project future trends in global climate change. In Antarctica, measurements were taken of very-low-frequency radio waves transmitted by the Soviet satellite Aktivny. Also in Antarctica, NSF's ultraviolet-radiation monitoring system was upgraded to provide a data centre with high standards of quality assurance.

10. Smithsonian Institution

The Smithsonian Institution conducts space science research at the Smithsonian Astrophysical Observatory (SAO) in Cambridge, Massachusetts, and at the Center for Earth and Planetary Studies and the Laboratory for Astrophysics at the National Air and Space Museum in Washington. The Museum's exhibits, lectures and education programmes contribute significantly to public understanding of space research. SAO also conducts programmes designed to improve pre-college science instruction and serves as the North American gateway for SIMBAD, the international astronomical computer database. The Roentgen satellite, launched on 1 June 1990, carries a High-Resolution Imager built by SAO to carry out detailed studies of cosmic X-ray sources. X-ray data on thousands of objects produced earlier by the Einstein (HEAo-2) satellite were converted to CD-ROM format and made available to all qualified scholars at no cost. Additional observations obtained during the slew mode of the Einstein survey, long believed to be unusable, were retrieved by SAO scientists and converted into a new sky catalogue. A rocket-borne SAO-IBM telescope produced the highest-resolution X-ray images ever obtained of the sun's corona; another instrument carried by a NASA balloon over Australia observed a host of X-ray objects, including the Crab Nebula and Supernova 1987a. And nearly two decades after Apollo astronauts returned samples of lunar soil, an SAO researcher identified a completely new rock type amidst the lunar material.

11. Department of State

The Department of State, through its Bureau of Oceans and International Environmental and Scientific Affairs, works with NASA on all international and foreign-policy aspects of American space programmes. Department of State activities during the period have included hosting a government-level review of international space station cooperation and negotiation of arrangements for space shuttle emergency-landing facilities in countries around the globe. The State Department's Bureau of International Communications and Information Policy has taken the lead in representing United States interest in INTELSAT and INMARSAT, two international organizations involved in space issues.